Department for
Business, Energy
& Industrial Strategy

EXPLORING THE VALUE OF DEFENCE JOBS IN THE UK

September 2017

Authors

Prabhat Vaze, Carolin Thol and Alex Fraser, Belmana

James Derbyshire and Maja Savic, Middlesex University

Acknowledgements

The authors acknowledge helpful comments throughout this study from the BEIS project team: Hala Elsayed, Keith Brook, Tom Reed and James Montagu at BEIS, John Ogilvie at MOD and from the academic reviewer. We are grateful for discussion with ADS Group, Infrastructure and Projects Authority, Ministry of Defence, Rolls Royce, Single Source Regulations Office and Thales.

Contents

Executive Summary

Middlesex University and Belmana Consulting were commissioned by the Department for Business, Energy and Industrial Strategy (BEIS) to study the value of jobs and skills in the defence sector, and their role in driving the productivity of the sector. The defence sector here is defined in terms of those companies involved in the design and manufacture of defence equipment and the research and development associated with this. BEIS commissioned this project to refresh, and develop further, the evidence base to support the government in assessing the costs and benefits of investment decisions in defence.

The research compiled a list of defence businesses. It then identified the jobs in the Annual Survey of Hours and Earnings where the employer was one of the defence businesses. The survey covers around 120,000 full-time jobs, of which just under a thousand are in defence businesses. The data about these defence jobs was analysed using a variety of approaches, which together present a picture of the value of jobs and skills in the defence sector. A wage premium is observed in the jobs in defence firms, which remains even when the calculation of the premium is in relation to “comparable” non-defence jobs.

A wage premium can be a proxy for high labour productivity, rewarding the added value of an employee in the defence sector who, in another job, would have contributed less to output. This may reflect the sector’s innovativeness, or its ability to capture markets abroad, or its operating scale. It may reflect also the distinctive nature of working in defence, such as the security clearance that individuals require to work in the sector. Work in defence is also often procured from a single source, procured without open competition to meet specific defence needs. This sometimes occurs in conditions of urgency, especially at times of military operations. A concern is also then that the defence premium may reflect a lack of competitive pressures in these circumstances.

The research primarily estimates the defence premium and the driver of premiums by analysing the defence jobs in ASHE in relation to all other jobs. The research carefully assesses whether the jobs are paid at a certain level because of the skills, experience, location and individual/company characteristics or because of something specific to defence, the “defence premium”. The results are corroborated by analysing the data in different ways. Additional work is presented comparing the defence jobs with a sample of matched non-defence jobs in ASHE that have similar characteristics. A second analysis focuses on the (relatively small) number of individuals who switch jobs into or out of defence to see if there is any pay change associated with switching.

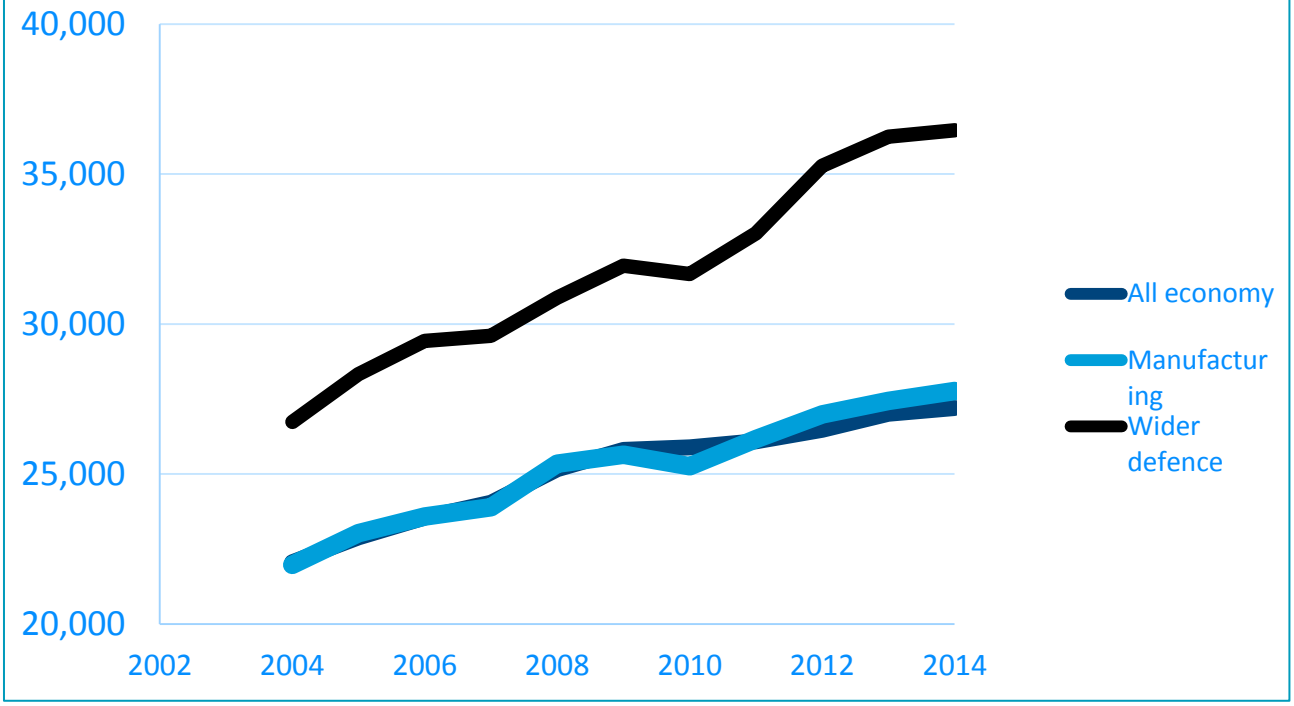
Trends in Defence Wages and the Wage Premium

BEIS research questions focused on how sector wages in defence compare to the average UK full-time wage and the average for the manufacturing sector. What has been the trend over the last 10 years? What is the 'wage premium' that the sector attracts? Do wages reflect skills and capabilities that businesses require in the sector?

The Office for National Statistics (ONS) Annual Survey of Hours and Earnings (ASHE) was analysed in different ways to answer these research questions. ASHE is a survey of employers which tracks the same 1% of individuals, collecting data each year about the jobs they hold.

- Figure 1 plots out the annual median gross pay in three sectors for 2004-14. It uses published ASHE statistics. The "wider defence" measure covers the industries where businesses typically supply UK defence needs, often alongside civilian uses (hence a "wider" definition). Wages paid in the defence industries have consistently been about 20-25% higher than both manufacturing and the All economy measures. The wage gap in pounds can be £10,000.
- Figure 1 indicates the wage premium is persistent over the decade. Only in a brief period after the recession is there any evidence of the wage premium reducing.

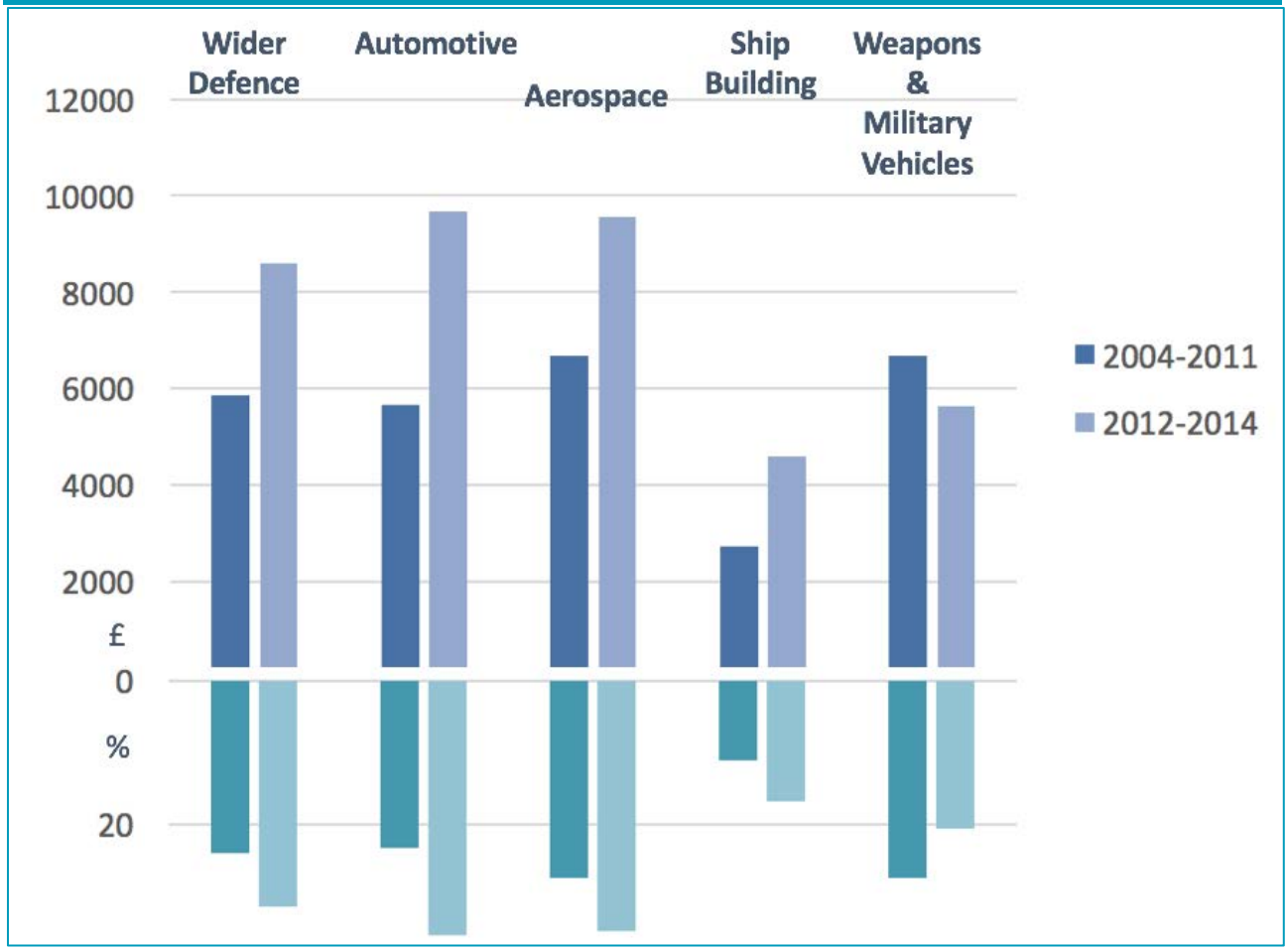
Figure 1: Gross Annual Pay for Full-time Employees (£ pa), 2004-14



Wider Defence is a weighted average across industry medians: Automotive (SIC 291), Aerospace (303), Shipbuilding (301), Military Fighting Vehicles (304) and Manufacture of weapons and ammunition (254). SIC 291, 301 and 303 will include employees working in businesses largely focused on civilian and military.

- Figure 2 separates the premium seen in 2012-14 from that observed in 2004-2011 using the published ASHE data. It also separates the wider definition of defence into the constituent industries. A large part of the driver for the premium rising in money terms is the general wage increases seen in manufacturing acting on an existing wage premium.
- The gap between wages paid in manufacturing and pay in the automotive, ship building and aerospace industries has increased the most. The sample size in ASHE for the weapons and military vehicles industry is quite small, but the premium has declined here.

Figure 2: Wage premium by industrial sector for full time employees



Wider Defence is a weighted average across industry medians: Automotive (SIC 291), Aerospace (303), Shipbuilding (301), Military Fighting Vehicles (304) and Manufacture of weapons and ammunition (254). SIC 291, 301 and 303 will include employees working in businesses largely focused on civilian and military. Source is calculations from published ASHE, annual, median, full-time pay estimates by SIC.

One novelty of this study is that it identifies defence employers and so the jobs in the ASHE survey that are in defence businesses. For 2012-14, this meant identifying under 1,000 full-time jobs as defence. This is about 0.7% of all full-time jobs covered by ASHE. The main results about these jobs are:

- The jobs in the defence businesses have a weekly average gross pay of £700, about £118 greater than all jobs in ASHE in 2012 or a premium of 20%.
- A simple comparison of pay in defence jobs to all jobs could reflect defence requiring higher skilled or experienced employees. The wage premium is estimated to be lower, at 5-12%, when it is calculated in relation to jobs requiring comparable skills and experience.
- The repeated surveying of the same individuals in ASHE means that individuals who change jobs can be identified. Those entering defence businesses received a pay rise 5% greater than those moving out of defence businesses. This is an alternative measure of the wage premium. The method does not need to adjust for people's skills and experience, as it same people switching into or out of defence jobs so that the pay change is on average only due to the change of sector.

The research considers how defence jobs differ from the wider set of jobs:

- The defence jobholder tends to be older, on average aged 43 while the wider full-time workforce is 41 years' old. An older workforce is likely to be more experienced.
- Defence jobs tend to be filled by men with 17.5% of jobholders being women; of all full-time jobs, 39% are held by women.
- Defence jobs are in establishments that are more capital intensive than other jobs; the jobs are also in manufacturing with only a third of the jobs being outside the sector.
- There are few defence jobs located in London, but there is a relatively high concentration in the Southeast. Much of the research focuses on pay levels and so this geography is important. London's wage premium is high and its impact spreads into the Southeast, so that the defence jobs in the southeast will attract some wage premium due to location.

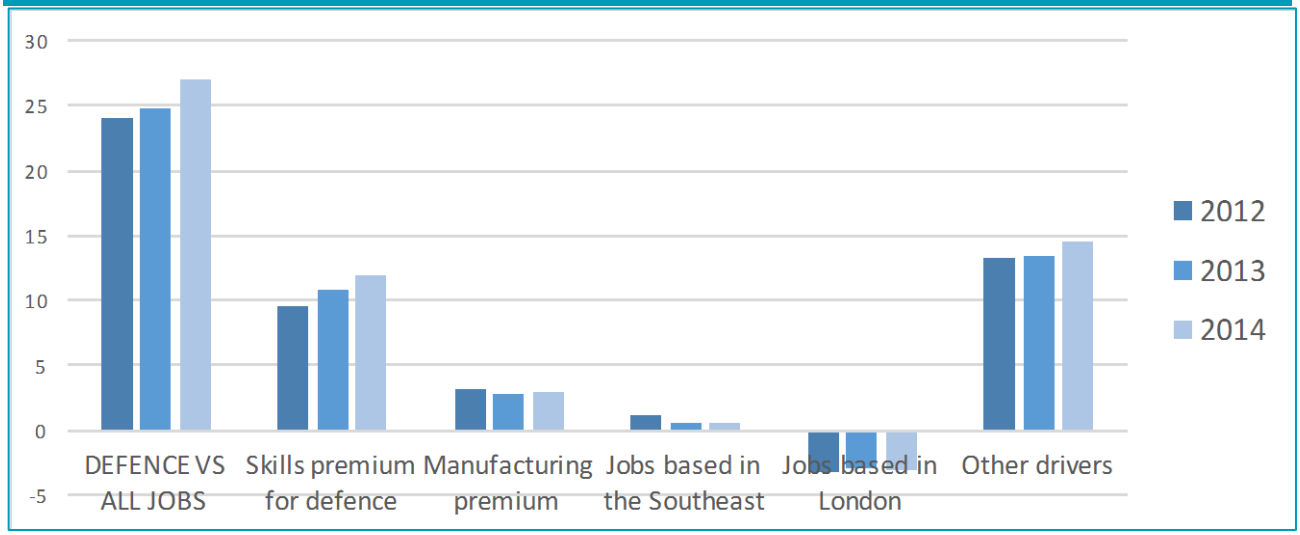
Driver of Defence Wages and Wage Premiums

A second set of research questions focused on drivers of wages in defence. Specifically, BEIS research questions were: what are the skills levels, relative to the rest of the UK and the manufacturing sector? Is there any significant spatial variation and does this matter? Is there any variation by business type or type of investment/product in the sector?

In ASHE, employers are asked about the occupation of each job. This has been linked to evidence from two surveys about the skills and experience associated with occupations and whether employers experience a shortage for the occupation. O*NET, a US survey, asks employers to score the occupations of their employees in terms of several dimensions of competency. The UK Employer Skills Survey asks employers about the shortages they face as they recruit:

- For the jobs in defence businesses, the most common occupation is Science, Research, Engineering and Technology Professionals. The 169 such jobs in defence businesses represent 3.1% of all the jobs in this occupation found in ASHE.
- More generally, the occupations associated with defence jobs are engineering related, often requiring high levels of skills, experience and knowledge.

Figure 3: Defence wages versus all full-time jobs: Contribution to premium (%)



- Figure 3 focuses on what drives defence jobs being highly paid, compared to all UK jobs. On the left is the wage premium noted above: defence jobs are paid about a quarter more than all other jobs.
- The occupations in defence consistently have higher skills/experience scores. It is estimated to increase defence earnings by 9-12%, using the ASHE results 2012-14.
- The defence jobs tend to be in the manufacturing sector and this is generally a better paid sector. This contributes about 2%.

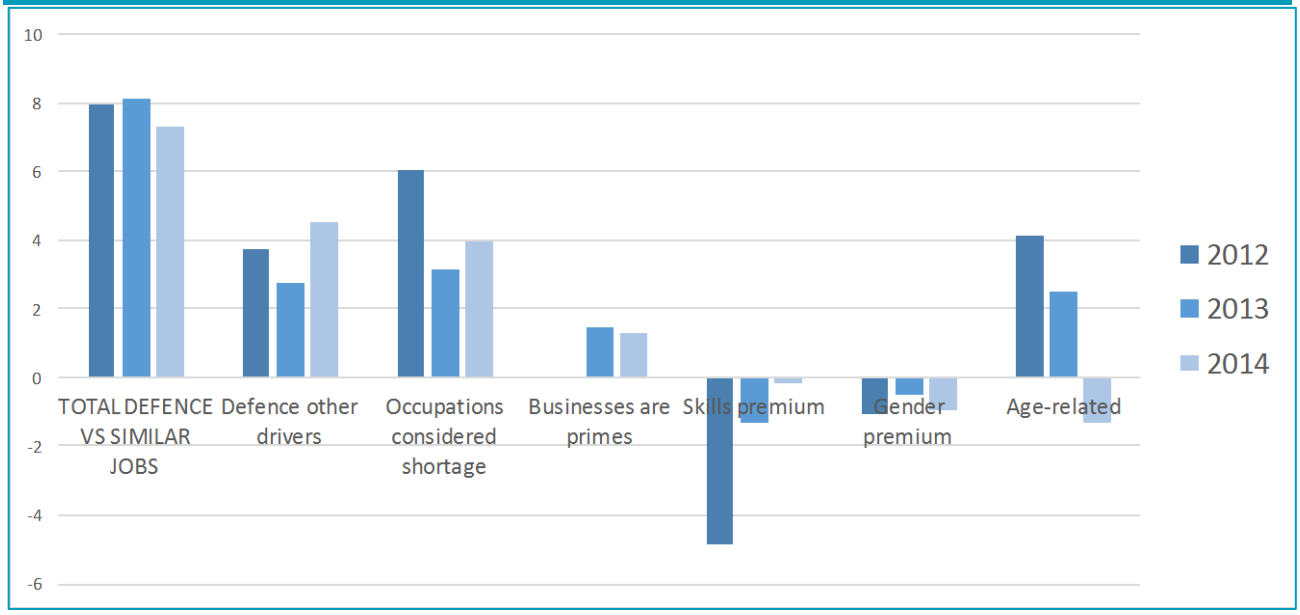
- The location of the jobs has an effect, but this operates in both a positive and a negative way. While many defence jobs are in the Southeast, which attracts a premium, this is outweighed by the fact that few defence jobs are in London, with London attracting a very high wage premium.

There is a wage premium of about 8-15% that remains after the pay in defence jobs is adjusted for the mix of skills, employee characteristics and employer/plant attributes of the jobs. There is an additional premium for the subset of defence jobs that are in clusters associated with the aviation sub-sector, primarily working on Combat Air systems. When defence jobs are compared to jobs outside defence but comparable in terms of these characteristics, Figure 4 indicates the drivers of the remaining premium:

- A portion of the defence premium is explained by businesses in the sector hiring shortage occupations. In general, across all sectors, where employers identify a shortage occupation, this correlates with a higher wage. However, in defence jobs this effect is enhanced, contributing about 4% of the defence premium over comparable non-defence jobs.

- The jobs in defence primes – these businesses lead large contracts for the Ministry of Defence – contribute about one per cent to the premium. Primes may benefit more from the single source procurement used in defence than other defence businesses, usually in a supply chain or in a market where competitive pressures are greater.The 2012 results indicate the importance of identifying apprentices, as the apprentice marker only occurs in the 2013 and 2014 waves of ASHE. Without this marker, the lower pay of apprentices is allocated to age (positively as apprentices are young) and makes the other drivers inaccurate, especially the skills premium.

Figure 4: Defence premium drivers comparing with similar non-defence jobs (%)



Leaving and Joining the Defence Sector

A final set of research question focused on what do individuals go on to do when they leave the defence sector, particularly engineers and the armed forces. How do their wages compare?

The repeated surveying of the same individuals in ASHE means that the people who change jobs can be identified. This can be used to measure the premium indirectly, as pay changes for an individual as s/he move between industries:

- Those entering defence businesses received a pay rise of 4.8% greater than those moving from defence businesses. Despite a relatively small sample size, this proves to be a statistically significant difference.
- Employees that stay in defence see an average annual pay rise of 3.5%. The pay of those that move from a defence job to one outside the defence sector rises 5.4%, higher but not statistically different from the rises seen in those that remained in defence jobs.
- ASHE – like most public surveys – does not sample the serving Armed Forces. It therefore remained beyond the scope of this study to look at the wage premium attached to military veterans.

Table 1: Evidence of annual pay changes for those switching from and to defence jobs, 2009-14

Pay change as individuals…		
…Take up jobs in defence businesses	+10.2%	
…Leave jobs in defence businesses	+5.4%	
…Stay in defence jobs	+3.5%	

Note: Increase in hourly wage rate for full-time employees in defence jobs plus those exiting defence. Significance tests for whether pay increases for movers different from stayers and secondly whether the rise for those entering jobs in defence significantly higher than those leaving defence businesses. ***,**,* significant at 1%, 5% and 10% respectively.

1. Introduction

The government's National Security Strategy (NSS) and Strategic Defence and Security Review (SDSR), published in November 2015, introduced "Promoting our Prosperity" as a national security objective. This included commitments to refresh defence industrial policy as one of several measures to help the UK's defence industry grow and compete successfully, to drive greater innovation in defence procurement and to ensure that future investment decisions contribute to a more dynamic and productive economy.

To support this work BEIS identified a need to better understand the contribution that the defence sector currently makes to the UK economy. BEIS commissioned this project to refresh, and develop further, the evidence base to support the government in assessing the costs and benefits of investment decisions in defence. The project could also support work to develop a methodology for assessing value for money in defence investment decisions (e.g. covering trade-offs between capability, cost and exportability).

The aim of this study is to better understand the value of jobs and skills in the Defence sector, and their role in driving the productivity of the sector. There are different definitions of what constitutes the defence sector. A wide definition covers the breadth of Ministry of Defence (MOD) procurement. Such definitions support analysis of defence spending, but – because of the nature of defence – extends the analysis into sectors that may not focus on defence and security related products or do not see defence as the core activity.

The defence sector here is defined in terms of those companies involved in the design and manufacture of defence equipment and the research and development associated with this. This narrower definition allows analysis to concentrate on how defence activity contributes to productivity, especially in its use of labour and the associated skills development, investment and R&D for defence.

The main research questions for the study are as follows:

1. How do sector wages compare to the average UK FTE wage and the average for the manufacturing sector? What has been the trend over the last 10 years? What is the 'wage premium' that the sector attracts?
2. Do wages reflect skills and capabilities that businesses require in the sector? Specifically, what skills levels on average do those employed in the sector hold, relative to the rest of the UK and the manufacturing sector, and what is the correlation with wage levels?
3. Is there any significant spatial variation? Does spatial employment in the sector matter?
4. Is there any variation by type of business (large, small, Prime, Tier 1/2)?
5. Is there any variation by type of investment/product in the sector?
6. What do individuals go on to do when they leave the defence sector, particularly engineers and the armed forces? How do their wages compare?

For this study, two key tasks were undertaken. First, a dataset of jobs in defence and, for comparison purposes, jobs outside defence was constructed. This contained the pay rate with the detail of the skills, age and gender of the employee as well as the size, location and firm

level characteristics of the employer. The second stage then uses this dataset to answer the research questions. A focus has been to understand the extent of any wage premium, defined as the difference between average wages in defence and a set of comparable jobs outside of defence.

The sectoral performance of the wages in defence sector are explored using ASHE in chapter 5. The study considers this performance in terms of key drivers for wages, such as skills, location and characteristics of the business (size and capital investment). The approach has then been to decompose the wage rates in terms of what portion of the wage is a defence premium understanding the drivers for this.

From a policy perspective, there has been an interest in two key areas. A first is what is happening in the labour market associated with Combat Air, large-scale naval procurements and with the parts of defence that necessitate nuclear-related skills and investments. Where possible, the study distinguishes results for the aviation centres, which largely produce or support Combat Air equipment, and the naval centres. This has been possible by distinguishing in the data the jobs that are in the clusters. This was not possible for the nuclear related jobs as there were too few in the dataset used in this study.

A second area of policy interest is the labour market in relation to the different tiers in defence procurement. The primes and tier 1 contractors are typically large, global defence businesses that lead major defence projects. As they are large employers, it was possible to mark in the data the jobs associated with these businesses and consider what effect there is from being in a prime on wages.

ASHE is a longitudinal panel, tracking individuals each year as they change jobs. It was therefore possible to understand what happens as individuals leave defence businesses and enter these businesses from outside the sector. The evidence on the number of people switching between sectors was somewhat limited by there being relatively few people changing jobs each year in the sample of defence jobs. Further, serving members of the Armed Forces are not included in ASHE and so little could be said about their transition from the military into civilian roles both inside and outside the defence sector.

2. Context and Key Findings

This chapter presents the context for the research and the key findings of the study. It describes the role played by the defence sector, particularly the suppliers of defence equipment and equipment support and the supply chain that underpins these businesses. It has benefited from discussion with experts that were interviewed during the research. The chapter summarises the evidence that the study finds about where defence jobs are located and the wage premium enjoyed by the employees of defence businesses.

The Defence Industry in the UK

Defence plays a special role in the UK economy for several reasons. It is a strong contributor to the manufacturing base, employing directly more than 140,000 people and providing places for 4,300 apprentices. It is an important export sector, with exports averaging £7.7 billion in 2010-14 (ADS, 2016). Moreover, it is strategically important for national security (HMG & DGP, 2014).

The defence industry's structure is shaped by its role supplying the UK's military capability. Competition is the starting point for the government in procurement, but single source contracting remains a prominent feature in the UK defence acquisition landscape. This is where the supply of a good or service is from one supplier because of its specialised or unique characteristic. There are military-strategic benefits of non-competitive contracting. It is associated with greater independence from other countries' procurement, sometimes conferring a defensive edge. Also, it offers greater security of future supply and the potential for equipment to be designed with the UK requirements as a focus. However, there are concerns that the reduced competitive pressure has a negative dimension. With a single purchaser and – in many instances – monopolistic supply, the reduced competition pressures might lead to a defence cost premium, and this is then translating into a wage premium for those working in defence.

Much of this study focuses on quantitative analysis of the drivers for any defence wage premium. However, the study has also benefited from discussions with experts from the Ministry of Defence, the industry body ADS Group, the Single-Source Regulations Authority, HM government's Infrastructure and Projects Authority and two leading defence businesses. The discussions were primarily around the drivers for defence pay, especially where this differed from other parts of the economy. It provided an important context to the study and this section includes the observations made.

Research has suggested that the UK's onshore defence industry provides a range of economic and employment benefits to the UK. Dorman et al (2015) noted that the sector is high-technology and high-value, finding that over half of the employees in UK defence companies are involved in R&D (22 per cent), or engineering and production and assembly (31 per cent). Defence sector experts highlighted some specific ways this impacts pay.

The interviewees for this study, firstly, noted that the high skills required in defence command a higher wage and that the qualifications of employees were at a high level. Secondly, defence businesses highlighted their investment in skills development, often in an environment where there was considerable competition for the individuals that benefited from the investments. A point made by interviewees was that defence products are tournament goods (described in

Davies et al., 2012), in that their use is in the adversarial battle environment. Defence will require battle-winning technologies and to produce winners, this tournament then drives the UK's defence industry paying a premium.

The defence industry forms a hub for generating science, technology and skills within the national workforce. For this reason, the government formed the "Defence Growth Partnership" with industry leaders in 2014, publishing an implementation plan in that year (HMG & DGP, 2014). One aspect of the partnership will be focus on skill development and utilisation. It will foster collaboration between industry, research and academia, as well as providing apprenticeships to attract more graduates into the industry. Interviewees noted that, like many other high-tech sectors, the defence industry suffers from a looming skills shortage as older engineers retire. There have also been questions about the talent pipeline, with calls for strategies to ensure there are enough students enrolled in the relevant subjects being complemented by pay incentives to retain experienced, older staff for longer (Retter et al., 2015).

Government bodies interviewed for this study have been considering these issues at a strategic level, seeking to understand the talent pipeline in the context of the programme of UK major projects envisaged in the coming decades. There are several very large defence programmes, such as the Successor and the Queen Elizabeth class carriers and associated investments. These projects would run in parallel with major UK energy and transport projects. A premium may emerge in defence pay signalling the competition for key engineering skills as demand rises. Discussions then considered the analysis needed to ensure such signals translate into supply of trained and skilled engineers improving in the defence sector.

Wage premiums in defence should be analysed in the context of several factors specific to defence. Firstly, defence production is clustered in certain areas, usually associated with important production infrastructure. For example, defence investments related to the submarine fleet are in Cumbria with associated employment. The supply chain for this cluster then extends to other areas, but a wage premium should be analysed recognising a job market may have locational specificity. Industry experts viewed the very localised nature of defence jobs as core to their human resource functions. They reported the extensive information gathering at a local level about labour market conditions, the collaboration with higher education bodies in training and the tie-in with local enterprise partnerships and strategic suppliers as a key complement to pay setting. It was also noted that a pay premium may be a consequence of this high level of skills building occurring in relatively segmented, local labour markets.

A further complication is that defence procurement routinely is under single-source procurement regulations. Where defence needs can only be met by a single supplier, procurement is then managed recognising that competitive pressures on costs – including pay of staff – will be limited. MOD writes into contracts many cost control and cost recovery clauses to compensate for this. These have recently been given more significance with the refreshing of the regulatory framework overseeing such contracts following the Currie Review (2012). The issue this highlights is that the wage-setting arrangements for defence jobs should be seen in the wider context of defence procurement.

Discussions highlighted the pay drivers due to this procurement route. The UK has had over a decade of active military operations and there has been a strong, on-going demand for military equipment. This has often been met through Urgent Operational Requirements, a fast-track for MOD to procure from single sources for operations. The urgency has implied costs and these are likely to manifest themselves in a wage premium as staff have met the increased and

urgent demands. Further, as operations have lessened, there is a need to understand whether the urgency driver has reduced to the extent of reversing the cost pressures.

Several discussions centred around the supply chain and whether any defence premium was conferred to employees of businesses outside the so-called “defence primes”. Primes are the lead suppliers in major equipment programmes, usually leading a consortium of tier 1 main suppliers and then sub-contracting to the wider defence supply chain. It is possible that procurement through a single source arrangement meant there was a wage premium in the lead contractor, usually a large defence prime. As the lead contractor then competes the works to lower tiers, the competitive pressure might be greater in the supply chain and so lessening the extent of any wage premium there.

These features of the defence sector could translate into an observable phenomenon: that a job in defence that is like one outside defence could be more highly paid. On the face of it, this would reflect either a failure in measurement (in that the job holders differ in some unmeasured way that explains the pay gap); or some market characteristic, or even lack of competitive pressure.

However, it may also reflect a productivity premium, with the job using the skills and expertise of the jobholder more effectively in creating value. In discussions with defence businesses, a typical example was employers’ recruitment at entry level. This targeted those that had some work experience, especially where that experience involved handling machinery. So, in agricultural areas, young people who had worked with farm machinery were switching industry. The switch would then lead to a better paid career, such as in maintenance of military equipment. The productivity-enhancement this causes has led to an interest in any wage premium that may exist, especially if it is accurately measured by taking account of the job holders’ skills and experience.

Key Empirical Findings

This study finds evidence of a wage premium for jobs in defence which is persistent over time: a job in the defence sector will attract a wage premium of between 5% to 12% wages over a similar job outside of the defence sector.

An important contribution to the difference in pay between defence jobs and non-defence jobs is the shortages in certain occupations. There is also some evidence that those employed in the defence primes, businesses that are directly contracted by the Ministry of Defence for large programmes, attract a pay premium. The analysis also looks at factors that cause defence wages to be high relative to the average UK job, confirming that this is largely due to the skills and expertise required in defence jobs.

The average pay of employees is reported annually by the Office for National Statistics (ONS) when it publishes the results of its Annual Survey of Hours and Earnings (ASHE). Over the past decade, this has indicated an annual gross pay premium for those parts of the manufacturing sector most closely linked to defence. The estimates cover the jobs in the Automotive, Aerospace and Shipbuilding, combining both civil and military use, and then add the jobs in the two military focused industries: Military Fighting Vehicles and Manufacture of Weapons and Ammunition. The pay in these jobs has consistently been higher than the pay in jobs found in manufacturing and the “all economy” category, by at least ten per cent and often being over 20%.

A concern in attributing this to defence is that many of the industries comprise a significant non-defence portion. Further, there are businesses supplying defence outside the industries

identified. Both may mean some imprecision in the estimates of any wage premium. Therefore, this study uses public lists of businesses with a strong defence focus identifying 1,335 companies. Of these, 1,155 were matched to a Companies House number and most of these were then linked to the ONS business register. In each of the years 2012-14, around 900 employees in these businesses were in the ASHE sample.

Attribution of a wage premium to a type of employer has several difficulties, primarily because it is inevitable that some aspect of a job remains unmeasured and that this may explain any wage difference. A statistically powerful way to control for this is to focus on those individuals that switch in and out of defence jobs. This neatly sidesteps many of the measurement issues. By observing the same person in a defence and non-defence job, any pay change can be attributed to the transition between sectors.

ASHE is a panel; in that it observes the same people each year tracking individuals through different spells of employment. Table 2.1 summarises the pay changes seen in the subsample of people who move into defence jobs from outside defence and those that move the other way. It also looks at those that stay in defence. It presents the most powerful evidence of a pay premium in defence, indicating that those entering jobs in defence business received pay rise of 4.8 per cent greater than those moving out of those businesses. This difference is significant at 5 percent confidence.

Table 2.1 indicates also that – while those staying in defence get an annual pay increase of 3.5% - those moving into defence jobs see a 10% pay increase. This is significant (at 1%). Those moving the other way, to jobs outside of defence, only see a 5.4% pay rise, which is not statistically different to the annual pay increase in defence jobs.

Table 2.1: Evidence of annual pay changes for those switching from and to defence jobs, 2009-14

Pay change as individuals…			
…Take up jobs in defence businesses	+10.22%	Greater than stayer***	Difference is +4.79%
…Leave jobs in defence businesses	+5.43%	No different to stayer	
…Stay in defence jobs	+3.49%	Stayer pay increase	F(1,3693) = 4.9, significant at 5%

Note: Increase in hourly wage rate for full-time employees in defence jobs plus those exiting defence. Significance tests for whether pay increases for movers different from stayers and secondly whether the rise for those entering jobs in defence significantly higher than those leaving defence businesses.
***,**,* significant at 1%, 5% and 10% respectively.

The skills, experience and geography of defence jobs means that comparing average gross pay of defence jobs with the wider ASHE sample is an inaccurate estimate of any premium. The 832 defence jobs in 2012 are likely to involve individuals that differ from the wider ASHE sample. Potentially, the entire pay difference could reflect not the fact that the employers are involved in defence but just that defence tends to have jobs requiring higher skilled or experienced employees. Were these individuals to move out of the defence sector, it may be that the individuals would find, on average, higher paid jobs.

Table 2.2: Decomposition of the Wage Premium			
	2012	**2013**	**2014**
Defence-specific wage premium			
Defence other drivers	3.7%	2.7%	4.5%
Occupations considered shortage	6.0%	3.1%	4.0%
Businesses are primes	0.0%	1.5%	1.3%
Skills premium	-4.8%	-1.3%	-0.2%
Gender premium	-1.1%	-0.5%	-1.0%
Age-related	4.1%	2.5%	-1.3%
TOTAL	**7.9%**	**8.1%**	**7.3%**
Premium due to defence job's attributes differing from UK jobs			
Skills premium for defence	9.7%	10.9%	11.9%
Manufacturing premium	3.2%	2.7%	2.9%
Jobs based in the Southeast	1.1%	0.5%	0.6%
Jobs based in London	-3.3%	-2.9%	-3.0%
Detail about skills premium associated with defence jobs			
Monitoring processes, materials and surroundings and selling and influencing	6.9%	7.2%	7.6%
Problem solving, negotiating, control, planning & prioritising	5.5%	5.5%	5.5%
Materials, Equipment & Technical	4.3%	4.3%	4.6%
Handling, inspecting objects, machines and vehicles, coordinating people	-2.7%	-2.8%	-2.5%

The top panel of table 2.2 indicates the results carefully controlling for this. It gives the premium for defence jobs over comparable jobs and then attributes the premium to the interaction of being a defence business and the different aspects of the job. This study finds two drivers/components of this wage premium are skills shortage and a defence employer being a prime. Where employers identify a shortage occupation, this correlates with a wage premium. However, in defence jobs this effect is enhanced, contributing about 4 per cent of the overall 7-8% premium in the table. Another feature identified in the table is that the defence firms identified as primes – these businesses lead large contracts for the Ministry of Defence – pay employees more than they otherwise would receive, given the skills, location age etc. associated with the role. This contributes 1% to the premium.

The wage premium seeks to compare a job in defence with one that is similar, but outside defence. The lower panel in table 2.2 indicates why this is important. Defence jobs are highly paid, compared to all UK jobs. In ASHE 2012, for the 832 jobs identified as defence jobs, weekly gross pay was £700, about £118 greater than all jobs in ASHE. Table 2.2 indicates that the jobs tend to be in the manufacturing sector and this is generally a better paid sector. The table indicates the location of the jobs has an effect but this operates in a positive and a

negative way. While many defence jobs are in the Southeast, the premium of working in the region is outweighed by the fact that few defence jobs are in London, with London attracting a very high wage premium.

However, the table highlights the main reason for defence jobs being paid well in comparison with the wider set of UK jobs. Generally, the skills and experience of the jobs in defence is higher than those outside the sector: the occupations in defence consistently have higher skills/experience scores and these are estimated to increase defence earnings by 9-12%, using the ASHE results 2012-14.

The report details the mix of skills and knowledge associated with jobs in defence, estimating its effect on pay levels. Table 2.2 suggests that a set of skills differentiate the defence jobs from the wider set of jobs. The occupations are associated with skills and knowledge that are focused on equipment production, including problem solving and process management skills. This correlates with the occupational breakdown found in this study. Defence jobs are more likely to be in occupations “Science, Research Engineering and technical Professionals”, “Science, Research Engineering and technical Associates”, “Skilled Metal, Electrical and Electronic Trades” and “Process, Plant and Machine Operatives” than the wider ASHE sample.

Defining and Estimating Wage Premiums

A wage premium is the amount by which some workers earn more than others, although they supposedly do the same work, have the same qualifications, or are similar in some other relevant way. The literature on wage premiums originates with research on the returns to education, establishing the value of an extra year of schooling or higher education. However, there has also been research on other kinds of premiums, for example the public-sector premium (e.g. IDS, 2013).

There may be an economic rationale for wage premiums in the defence sector: the defence industry can capture economic rents, partly because many of the firms are specialists in their fields, customising products to the needs of the UK Ministry of Defence. Efficiency wages could also play a role in wage setting in the defence sector. As firms are highly specialised, workers acquire sector-specific skills, that can also be valuable in adjacent sectors, such as related civil sectors. To reduce turnover and reduce the loss of intellectual property, firms may choose to pay higher wages. Lastly, there could also be undesirable aspects related to the defence sector that workers would want to be compensated for. This could include, for example, the need for security clearance or the costs associated with the confidentiality of the work.

What makes the discussion of a premium complicated is that it is hard to define what constitutes a “premium”. If a worker with a higher qualification or greater experience than his/her colleague performs better, the price of the labour should be higher. However, if they perform the same work and produce the same value, but one gets paid more because of his/her degree, this could constitute a premium. Similarly, it has been argued that workers in the public sector get paid more than their counterparts who do similar work in the private sector.

The concept of a “counterpart” poses another problem. Observing two workers at an assembly line in the same plant makes it easy to establish that they perform the same work with the same output. However, in a world with a lot of different occupations, it is much harder to compare like with like. When comparing wages, it is also important to consider wage structures. In some industries and occupations, bonuses, overtime pay and other perks such as health insurance and pension contributions are common, while they do not exist in others.

These should ideally be considered in a fair comparison of wages, but data may not be available, especially as pay rates remain a sensitive issue.

Wage premiums are also likely to change over time as supply and demand of certain skills in the economy change. For example, Kleibrink and Michaelsen (2011) show that in the UK, the higher education premium has decreased over time, especially for lower quality degrees and bachelor degrees compared to masters or PhD degrees.

It is much harder to control for differences in skills and experience. For the public-sector wage premium, IDS (2013) find that after controlling for education, experience and responsibility, an apparent difference between public and private sector wages disappears. However, even variables such as years of education and qualifications capture only a fraction of the requirements of a certain employee in a certain position. Information about role-specific experience, for example, is almost impossible to capture.

A combination of carefully defining possible roles and then linking to each role the skills and experience it requires has been one way in which the complexity of making different jobs comparable. In the US, surveys have been conducted to establish how comparable different jobs are by asking employers about the main jobs in their businesses. In the UK, the Employer Skills Survey provides information from the employer perspective on this, as it asks employers about the reasons behind vacancies that prove hard to fill. Therefore, it shows to what degree certain skills are in especially short supply.

The existence of a pay premium for the defence sector in the UK has important implications. On the one hand, a wage premium could be an indicator of a skills shortage that should be addressed quickly to enable the industry to grow and meet future demand. On the other hand, spreading knowledge of this premium should make the sector attractive. If the premium can be explained by special skills and experience present in the workforce of the defence industry, this fact can also be used to shape skills policy.

For policy making, wider impacts of investment are considered, especially as government expenditures support jobs in specific sectors and areas of the country. Under certain circumstances, the evidence for a wage premium can support public policy decisions. This study provides a more detailed understanding of the value of jobs and skills in the defence sector, contributing to the debate about their role in driving productivity in that sector.

As noted above, any premium estimate is only high quality if the matching of jobs in the defence sector is accurate. This presents three challenges. A first is defining the defence sector meaningfully. Defence procurement is often a starting point, but much of what defence procures is not purely “defence”, such as the procurement of back office functions. Further, the defence sector extends beyond the prime contractor, with a long and complex supply chain. In chapter 4, the approach to meet this challenge is described. Lists of businesses involved with MOD procurement are combined with lists of firms that describe themselves as defence-focused. A range of tests have then been developed to refine the combined list of businesses. However, the key role of this work was to be able to link the businesses – using the Companies House and ONS business identifier – to an annual ONS survey about UK jobs.

The second challenge is about what characteristics to use to match across jobs, developing a wider dataset with the relevant variables. Matching will usually start with occupation, identified by the standard occupation classification (SOC) code. A difficulty of this approach is that occupations are very diverse. Even those that appear comparable on the 4- or 5-digit SOC code level can entail different skills and tasks across different sectors (IDS, 2013). Therefore, rather than relying only on occupation, researchers have started to consider education,

experience and responsibilities. Chapter 5 explains how this study uses employer surveys to characterise the different occupations in terms of the skills and competencies needed. There are several surveys that ask businesses about the jobs of their workforce, and these can be linked to the occupation codes for jobs.

The third challenge is the technical aspects of determining which jobs should be compared to those in defence to estimate any premium. Once variables about jobs have been compiled and the wage rates calculated in a comparable way, selecting the jobs that are like those in defence in all aspects except the sector requires selecting a matching method and then ensuring its robustness. In this study, different approaches have been used.

A first looks at the small sample of individuals who switch in and out of the defence sector. The fact that the individuals move means that looking at any change in wage level neatly avoids having to control for the characteristics of the person. It allows the analysis to focus on the wage impact of moving between sectors. However, the more detailed analysis needs larger samples and job switchers are relatively rare. So, the study uses wage equations. These statistically model the wage rate in terms of the characteristics of the employee, the employer and the attributes of the job. The results are in chapter 5.

3. Identifying Defence Businesses

Past studies about the jobs in defence related businesses have relied on published statistics. The studies first identify which industries in the standard industrial classification (SIC) have a significant defence component and then estimate key statistics, such as employment and wage rates, across these industries. However, standard classifications have limitations, a main one being that many industries are defined in a manner that does not reveal the user of their products.

This study created a list of defence firms based on sources that identify individual firms that are supplying defence products or marketing to defence purchasers. The list is then linked to business registers and firm-level data. This allows analysis of the jobs associated with defence at a detailed level.

The study uses a four-stage method to identify firms in the defence sector. The four stages are:

- Merge lists of businesses potentially in the defence sector removing duplicates;
- Link to the Companies House register to provide each firm's identifier – needed for linking to ASHE and other business surveys in later analysis;
- Quality assure the linking process; and
- Create variables about the "defence-ness" of the firm using public sources.

Evidence on Defence Sector Businesses

Lists of Defence Businesses

To construct a list of UK defence employers, a first source is the Ministry of Defence (MOD) procurement data, which details the main suppliers to the MOD. For the years 2012-2013 and 2013-2014, MOD published a list of contractors with contract values greater than £5 million. There were 340 entries in 2012 and 337 in 2013. Across both samples there were 408 unique contractors.

The list is first "cleaned", removing foreign government bodies and international organisations, such as NATO. Second, a contract with the MOD does not mean a business is defence-focused. For instance, the sample contains large accountancy firms, where the business, and so most of the employees, are likely to be working for non-defence clients. It would be impossible to identify the jobs related to defence work and the firm's jobs are then unlikely to provide evidence about a defence premium. Thirdly, this source is biased towards the bigger firms as it focuses on contractors making sales of over £5 million to MOD. To some extent, this is an advantage as they are likely to be the largest employers so increasing the coverage of defence jobs in the study.

A fourth issue is that businesses further down the supply chain are likely to be missed. For this final issue, other sources of defence businesses have been identified. The study integrates the companies that are members of ADS Group, the industry body for the aerospace, defence, security and space sectors. Such a data source is valuable in that businesses, in becoming a

member of the trade body, define themselves to be in the sector. However, the source can cover civil aerospace and organisations with a primary interest outside defence though having significant aerospace and defence sales. Also, the source is not curated extensively. When clerically checking this list, companies appear that have dissolved or merged with others, yet are still considered members.

A more defence-focused list of businesses is the exhibitors at the Defence and Security Equipment International (DSEI) event. This is a trade show with a specific focus. The exhibitors are a mix of the largest businesses and smaller suppliers. One feature of this list is that it provides evidence about the diversity of industries – in the industrial classification sense – that are in defence and security. For example, textile businesses that supply military and security uniforms appear at DSEI but standard classification systems would place these businesses and their employees in non-defence industries.

Commercial databases of businesses usually classify the business both using official systems such as SIC and then integrating other information. A list of businesses in defence and aerospace was drawn from InfoBase, which provided other fields, such as location and descriptions. The location meant removing businesses that – while operating in the UK – had no employment in the UK; the description was analysed to understand if the business was primarily civil aerospace.

Identifying Companies House Numbers and Assuring the Matching Quality

The next step was to add the Companies House numbers for each of the 1,335 companies. For this, an automated matching process found many firms and – because numbers remaining were modest – this was followed with manual Companies House web search and other portals such as Company Check.

Where businesses could not be matched, the clerical search generally identified why this had occurred. Some businesses appear on UK defence lists but are registered outside the UK; some are located outside the UK with no operations in the UK. There are some businesses with complex ownership structures, including consortia of companies and government bodies. Some standard issues emerge also over time, with companies changing ownership and/or structure, such as those dissolved or merged and renamed, meaning that any direct links are dead.

Table 3.1 indicates the number of companies that could be linked to Companies House from each of the lists. In total, all but 158 entities could be associated with a Companies House number. Next, the observations were merged with the variables in the Companies House database. From the 1,335 companies that make up our sample of the UK defence industry, 1,155 were matched, leaving 180 unmatched. Most these 180 are the 158 observations without a Companies House number. The remaining companies have Companies House numbers but are now dissolved or foreign companies acknowledged with special codes but which are not contained in the UK database.

The quality of this matching was checked by taking a random sample and checking for false matches. The merging of the sample of defence firms and the Companies House dataset was successful, as there were no false positives.

Table 3: Industries of Defence Businesses

Source	Description	Strengths	Issues	Linked
MOD2012	Suppliers to the MOD in 2012/13 where sales exceeded £5m	Supply to MOD "necessary but not sufficient" indicator of defence-ness of business	Includes non-defence businesses and special entities supplying defence	329
MOD2013	Suppliers to the MOD in 2013/14 where sales exceeded £5m	Covers diversity of businesses that supply defence outside defence manufacturers	Only direct suppliers so missing the wider defence supply chain	327
ADS	Members of the Aerospace Defence Security and Space industry group	Membership means businesses self-define as aerospace/defence	Need to remove the civil aerospace businesses	1012
INFOBASE	Extract of defence and aerospace category from the commercial database.	Additional descriptors available to both refine identifying as defence and to link to Companies House.	Need to remove the civil aerospace businesses. Focuses on larger businesses;	302
DSEI	Exhibitors at the 2015 Defence and Security Equipment International trade show	Covered small businesses in supply chain and focuses on businesses in security and defence	Difficult to link to Companies House where businesses are small, new or non-UK	492

Indicators of Defence-ness

Table 3.2 gives one of the main indicators of the businesses' industry, the primary SIC as reported in the commercial database FAME and Companies House. It focuses on the businesses identified in the defence sector using lists from MOD and ADS and indicates that the firms are categorised to a variety of industries. Traditionally, the defence sector has been defined as industries in SIC 354, 291, 301, 303, 304 and 6440. These are the manufacturing SICs with a marine, aviation and vehicles focus and the sub-categories covering armoured or military use. The 6440 is the defence activities SIC. However, table 3.2 shows some SICs outside this to be quite common.

Table 3.3 explores linking the identified businesses to the FAME database about employment and turnover in the larger UK firms. Again, the focus are the MOD and ADS sourced businesses. As FAME is restricted to the largest firms, of the total 1,155 businesses, only 572 businesses have employment in 2015 recorded. The average is high, at 2,365 employees. In total, these businesses employ 1.4 million people. This number is clearly an upper bound for defence jobs, covering all firms that supply defence including those that sell products of a non-military nature to defence. Further, the jobs are those associated with the entire business, and not just the jobs associated with any defence-related work.

Table 3.2: Industries of Defence Businesses

Standard industrial classification code and description		Frequency
82990	Other business support service activities n.e.c.	77
70229	Management consultancy activities (non-financial)	49
62020	Information technology consultancy activities	46
32990	Other manufacturing n.e.c.	42
74909	Other professional, scientific and technical activities n.e.c.	37
26110	Manufacture of electronic components	35
70100	Activities of head offices	32
30300	Manufacture of air and spacecraft and related machinery	30
84220	Defence activities	25
62090	Other information technology service activities	24
25620	Machining	23
25990	Manufacture of other fabricated metal products n.e.c.	23
62012	Business and domestic software development	23
96090	Other service activities n.e.c.	20
None	Not supplied	76

This is evidenced by looking at the ADS list. There the focus is on suppliers to the defence related activities of MOD and the supply chain to these businesses. The employment would then exclude suppliers of a more general nature, such as business service firms. The 140 businesses that report an employment level – average is 1,820 – then have total employment of just over 250,000.

These two extremes are because the MOD supplier list – focusing on sales of £5 million to MOD – covers all industries and is less sensitive to whether the business is primarily a defence related supplier or not. The table also indicates how the amount of revenue from products sold to MOD can be used as an indicator of the "defence-ness" of a firm. By dividing the overall business turnover with that sold to MOD, some idea of the importance of the defence sales to the overall business can be derived.

The research involved experimenting with such indicators, alongside the primary and secondary SIC's to provide different sub-samples of the defence businesses that will be used in the further work. The preferred definition was all businesses excluding the large MOD suppliers whose sales to MOD was less than 15% of their turnover. A narrower definition then focused on the MOD supplier only, identifying these are tier 1/2 or prime suppliers.

Table 3.3: Employment and turnover of defence businesses

Sample	Characteristic/indicator	Average	N=
Whole	Turnover of businesses covered by MOD and ADS	£58M	639
	Employment of businesses covered by MOD and ADS	2,365	572
	Number of businesses in SIC 254, 291, 301, 303, 304		42
ADS	Turnover of businesses covered by ADS	£31M	419
	Employment of businesses covered by ADS	1,820	140
	Number of businesses in SIC 254, 291, 301, 303, 304		26
MOD	Turnover of businesses covered by MOD in 2012	£1.2B	269
	Employment of businesses covered by MOD in 2012	4,695	188
	Number of businesses in SIC 254, 291, 301, 303, 304		23
	Turnover of businesses covered by MOD in 2013	£1.1B	269
	Employment of businesses covered by MOD in 2013	4,362	207
	Number of businesses in SIC 254, 291, 301, 303, 304		23

Summarising the Identified Defence Businesses

The next chapter describes the data underpinning this study. Each year, one percent of UK employees is sampled and their employers are surveyed about the jobs. Table 3.4 presents summary statistics for the 2012 sample of full-time jobs. It also presented the sub-sample of jobs that are in the defence businesses.

Table 3.4: Summary statistics for full-time jobs, ASHE 2012

		All businesses			Defence businesses
Variables	**Unit**	**Mean**	**s.d.**	**Observations**	**Mean**
Gross pay	£	502.3	333.2	117012	639.0
Age	Year	40.869	11.873	117039	43.177
Gender (females=1)	Proportion	0.411	0.492	117039	0.175
Total hours	Hours per week	39.055	5.962	117039	39.456
Average capital expenditure, all assets	3-yr log average	3.891	40.518	116944	6.454
Defence businesses (=1)	Proportion	0.007	0.084	117039	1.000
Manufacturing (=1)	Proportion	0.119	0.323	108997	0.668
Defence prime (=1)	Proportion	0.002	0.046	117039	0.297
Shortage occupation (=1)	Proportion	0.390	0.239	109760	0.451
Private sector (=1)	Proportion	0.680	0.467	117039	0.996
Employment	Jobs	15351	38245	117030	5732
Log Employment	Log	7.085	2.842	116935	7.099
Size (Large=1)	Proportion	0.620	0.485	117039	0.578
London	Proportion	0.162	0.368	117039	0.042
Southeast	Proportion	0.135	0.341	117039	0.274

As the Annual Survey of Hours and Earnings is an employee-employer survey, it tends to focus on the largest businesses. Taking one per cent of all employees means that all large businesses are included but only about 3% of SMEs. This is borne out by the average size measures in table 3.4, Employment is 15,351, with 62% of businesses being large. The businesses defined as defence businesses are also large (58%) with just under 6000 full-time jobs.

Defence jobs differ from the wider set of jobs in several aspects:

- The jobholder tends to be older, on average aged 43 while the wider full-time workforce is 41 years' old.
- Defence jobs tend to be filled by men with 17.5% of jobholder being women; in the wider set of full-time jobs, 39% are held by women.
- Defence jobs are in establishments that are more capital intensive than other jobs; the jobs are also in manufacturing with only a third of the jobs being outside the sector.
- Defence jobs are more likely to be in occupations that employers consider shortage, with 45% being in shortage occupations versus the general picture of 39%.

4. Methodology and Data Sources

The wage premium associated with a sector or group is usually defined as the difference in pay in a sector/group compared to those outside that sector/group. This chapter looks at approaches to estimate wage premiums. It highlights how each need specifically compiled data about individual jobs, separating out those in defence from all other jobs and providing a high-quality estimate of the wage rate for the job. The data is supplemented by a range of characteristics about each job.

The wider literature on estimating a wage premium is reviewed in an annex. The chapter describes the data about pay used for the study, the ONS Annual Survey of Hours and Earnings.

Annual Survey of Hours and Earnings

The main source of data used in the approaches to estimate wage premiums is the Annual Survey of Hours and Earnings (ASHE). This is the Office for National Statistics' (ONS) principal source for earnings estimates, collected in April of each year, and uses data on about 120,000 full-time employees.

The sample selection is based on the National Insurance identifier, selecting all jobs held by one per cent of all NI numbers. HM Revenue and Customs shares with ONS the employer details for these jobs and ONS then asks the employers to fill out an ASHE record for each person identified. The largest employers, such as some of the largest defence firms, will definitely be surveyed, and about 1% of their employees will be recorded in ASHE. ASHE excludes serving members of the Armed Forces. Outside of that, the main category of employees that would not be included, part-time and/or low-paid employees who fall below National Insurance thresholds, fall outside the scope of this work which concentrates on full-time employees.

As the primary source of data is ASHE, there is a choice of the earnings measure. This study uses weekly earnings (including overtime) for employees. The modelling often relies on a regression of log-weekly earnings with the characteristics about the jobs that ASHE collects, namely: gender, age, location, sector and occupations. By linking the ASHE responses to other business surveys, a wider set of variables about the employer has also been used. For example, the capital expenditure associated with a business may be a significant explanatory variable of productivity and in turn wages. This has been added to the dataset by linking ASHE to the ONS Annual Respondents Database (ARD).

Estimating Wage Levels Controlling for Skills and Experience

The first approach to estimating a wage premium focuses on modelling wage levels, using the ONS Annual Survey of Hours and Earnings. Simple estimates of wages in comparison groups have the problem that the two groups are made up of a variety of different jobs and types of people. Using a raw average of mean hourly pay in both to compare earnings is often misleading, reflecting differences in the experience and skill levels associated with jobs, as well as the qualifications of employees. The location of the job can also be important.

This approach improves estimates of any wage premium by taking account of the comparability of jobs inside and outside the sectors of interest. An initial method is to select a few key variables, such as industry, and then to compare average wages. This can then be greatly improved through econometric estimation using job-level data and then controlling for the effects of employee and employer characteristics. This estimation then determines any remaining wage effect as attributable to the job being in a sector.

Examples for this include Damant and Jenkins (2011) and ONS (2015) that focus on the public sector/private sector wage premium. While these studies only use ASHE, the studies by Bryson (2002), and Trotske (1994) move beyond this single dataset linking in other surveys about the employers.

While a simple regression model provides considerable evidence, the study also uses a two-stage approach to confirm the results of the wage equations. The first stage matches each defence job with a comparable non-defence job using propensity score matching (PSM). After PSM, the jobs in the matched group will have similar characteristics to those in the defence group, in terms of observable characteristics. So, as defence jobs tend to be filled with older, male workers, the matched group would include jobholders that have a similar average age and gender mix. In this work, a key factor to match on is the skills mix – defence jobs are later shown to have a higher level of competencies than is the case across all jobs.

The second stage then compares the average wage in the defence jobs with the matched sample that has been constructed. The advantage of this method is that it tests – in the first stage – whether there are comparable jobs to the ones in defence. PSM can provide a robust comparison group but only if some assumptions hold. For example, there would need to be a similar non-defence job for each of the defence jobs. Whether this assumption holds can be tested. An annex indicates the results of these tests showing it has been possible to match the defence jobs to non-defence comparable jobs.

Using Data on Job Switches to Estimate Wage Premiums

A second approach improves the extent to which the comparison controls for worker characteristics. It uses panel data that tracks individuals each year as they have spells of employment. By following an individual, the approach can sidestep the fact that many employee characteristics are often unobservable. The approach then focuses on those employees that switch jobs between the sector of interest and the wider economy. Any change of wage rate is then attributable to the movement between sectors. This can be assumed because the worker characteristics are the same. Examples that use this approach include Disney and Gosling (1998, 2003), Girma and Gorg (2006).

ASHE is also a longitudinal panel. Like many annual so-called employer-employee surveys, ASHE tracks the same employees each year. This is because the survey samples from the tax register and always selects the same 1% of employees, identified by the fact they have a specific final two digits in their National Insurance numbers. This means that ASHE as a panel can track an individual through spells of employment, including the leaving of a job and then subsequent spells of employment. Where these are in a different sector, the change has some particular estimation advantages for looking at wage premiums.

The key advantage of this data is that the employee – as s/he moves job – is unlikely to have any change in characteristics bar those related to the additional year. This would be about both observable characteristics and unobservable, so any change in wage is primarily due to the switch in jobs. Where employees move from the sector of interest to another sector, any

change in wage would be driven by the change in employer rather than employee characteristics, so that modelling can focus on estimating the wage premium only controlling for employer aspects.

The problem with this approach has generally been regarding the number of observations that can be found in surveys such as ASHE. The sample size could be small for all but the largest groups of employees because job change into or out of a sector may not be frequent. Further, the data about the job change itself may be inadequate. There remains the risk that a measured premium is explained by unobservable factors, such as self-selection into the sector or the ability of firms to recruit the best graduates. This could be the case due to a challenging working environment, relative job security, the prestige associated with defence or any other unobservable factor. Researchers have then explored various instances where these two problems can be overcome. Sometimes a sector switch is forced on an employee: Gibbons and Katz (1989) and Abowd et al (2013) look at the wage effects of firm closure as employees en masse leave the sector where a business has closed.

5. Wage Premium Estimates

The ONS Annual Survey of Hours and Earnings surveys a 1% sample of jobs in Great Britain, including those in defence businesses. This provides the occupation, the pay and the hours of work for around 120,000 full time jobs. The survey can also be linked to the employer business and so identify any jobs in the businesses considered to be supplying defence products. This means ASHE can be used to estimate any wage premium associated with jobs in defence when compared with those outside of defence. This chapter indicates some results of this, using different approaches to quantify the premium.

ASHE surveys the jobs, for a specific reference week each year, associated with a one per cent sample of National Insurance numbers. The survey provides a comprehensive set of data about GB jobs. Exclusions are minimal: serving members of the Armed Forces are exempt. Further, some jobs do not require an employer to make a return to HMRC, usually because the pay associated with the job is below tax threshold.

Table 5.1: Wage premium estimates for Defence jobs

Design	Year	Defence Premium	Additional Maritime	Additional Aviation
Defence jobs matched to non-defence using PSM	**2012**	8%***	1%	19%***
	2013	5%***	3%	8%*
	2014	12%***	5%	11%
Regression of wages on defence dummy plus skills, age, location variables				
All defence business jobs	**2012**	12%	3%	11%**
	2013	11%***	3%	10%***
	2014	7%***	8%	15%***
Defence businesses restricted definition	**2012**	14%***	n/a	n/a
	2013	13%***	n/a	n/a
	2014	14%***	n/a	n/a

*significant at 10%, **significant at 5%, ***significant at 1%. Regression results and propensity score match used age, gender, O*NET, ESS shortage and hard-to-fill variables and the size, capital expenditure and location of the business The restricted definition excluded firms likely to be mainly civilian, removing ADS members but who did not participate in the defence focused DSEI.

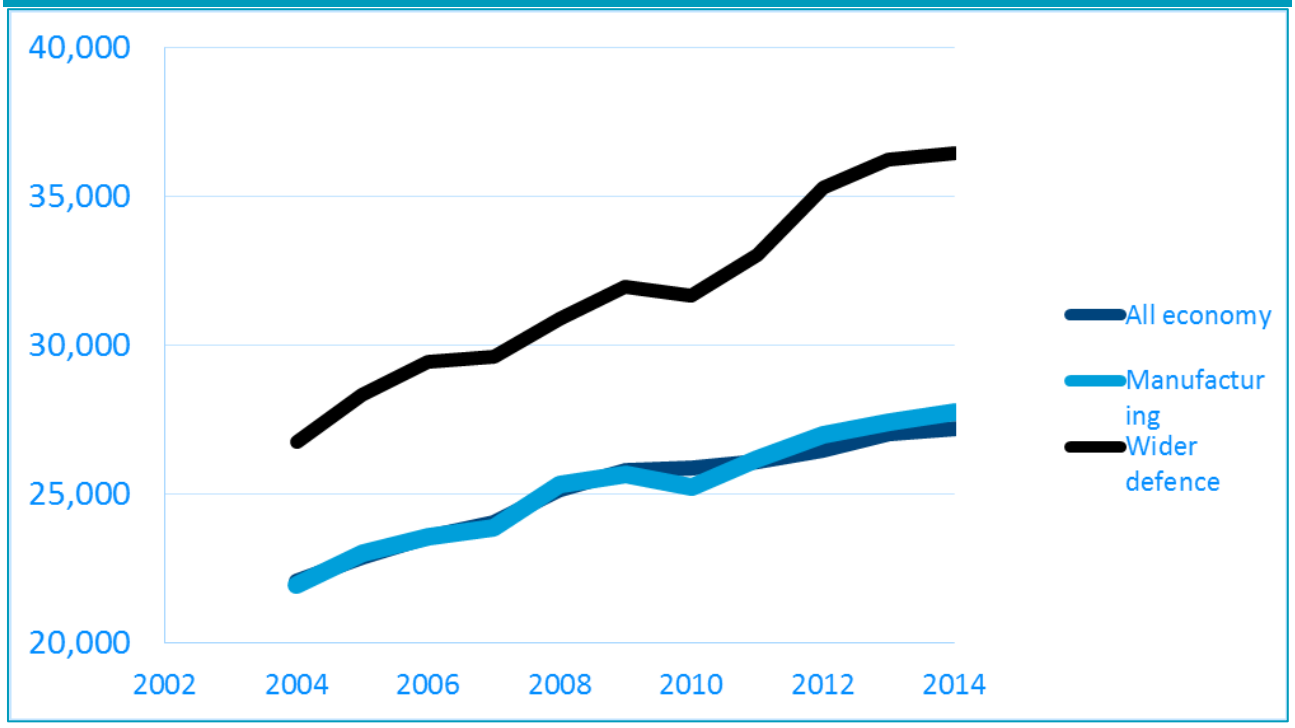
The employers are asked to supply the occupation, location and pay associated with the job and the gender and age of the employee. The data on individual jobs can be linked to details about the employer and table 5.1 indicates results when the wage premium in jobs in businesses identified in chapter 3 as “defence” is estimated. Two results are found: each estimation supports a premium of around 5-12% for defence jobs. Further, there is no

additional premium for jobs located in centres of maritime employment (such as naval dockyards), while there is one for aviation related employment. These are additional, so results indicate that a naval premium exists, but it is no different to that seen in other areas of defence. Finally, a more restricted definition, focusing on businesses that may be considered prime suppliers (or Tier 1/2) has a similar level of pay premium. This chapter details these headline results.

Trends in Annual Pay Levels

The pay of employees is reported annually by ONS when it publishes the results of its Annual Survey of Hours and Earnings. Figure 5.1 plots out the published annual median gross pay of all respondents, those in manufacturing industries and those in five industries often regarded as supplying defence.

Figure 5.1: Gross Annual Pay Full-time Employees (£ pa), 2004-14

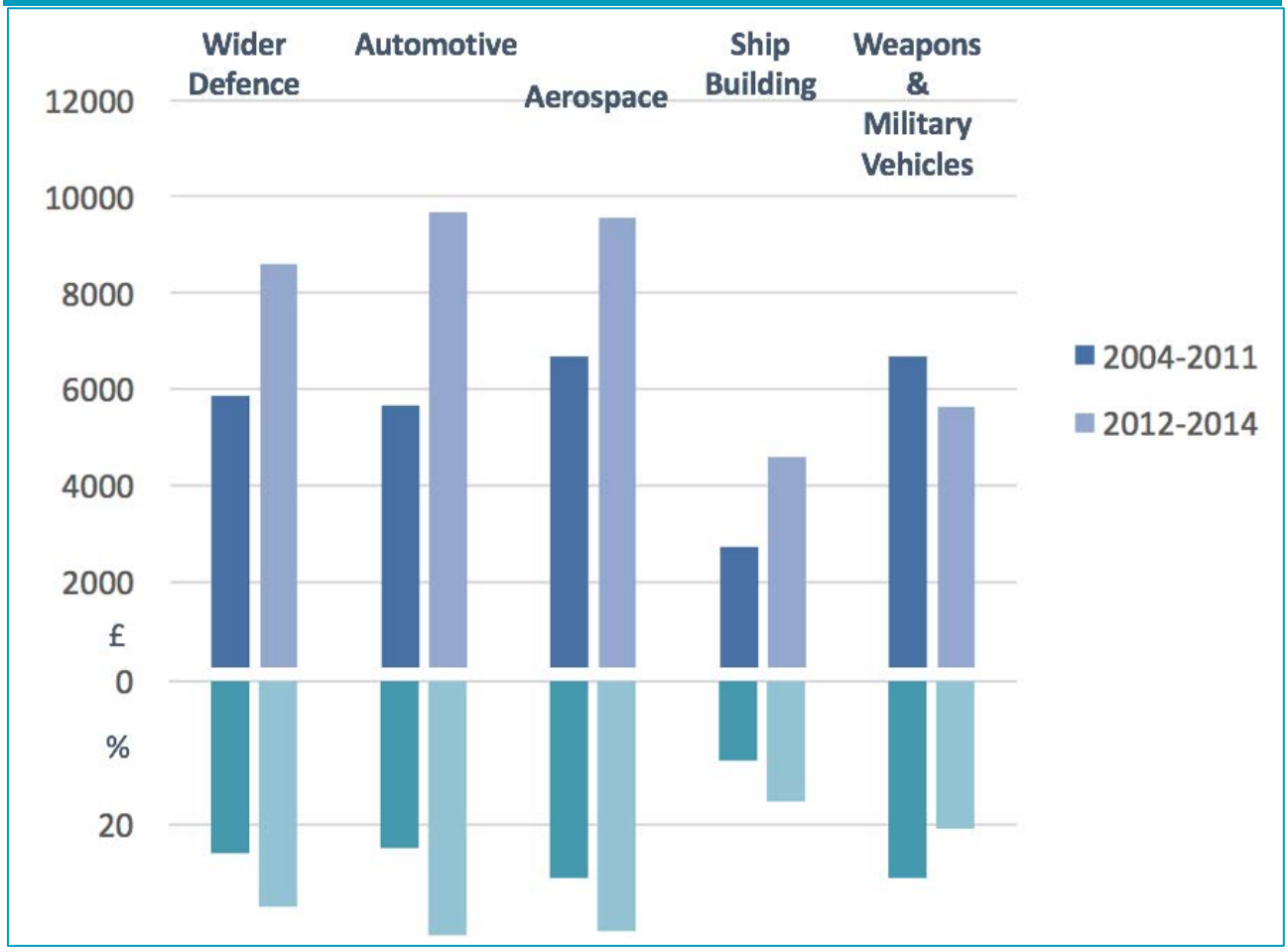


Wider Defence is a weighted average across industry medians: Automotive (SIC 291), Aerospace (303), Shipbuilding (301), Military Fighting Vehicles (304) and Manufacture of weapons and ammunition (254). SIC 291, 301 and 303 will include employees working in businesses largely focused on civilian and military. Source is calculations from published ASHE, annual, median, full-time pay estimates by SIC.

The highest pay is related to jobs in automotive, aerospace and shipbuilding, covering both civil and military use, and combining this with the businesses in the two military focused industries, Military Fighting Vehicles and Manufacture of weapons and ammunition. This is titled “wider” defence because it is likely that many of the jobs are related to production for civilian use.

For comparison, the All economy and Manufacturing industries ASHE results are presented. The main notable features of making this comparison is that the wider defence measure has consistently been higher than both manufacturing and the All economy measures, by at least ten per cent. There is persistence in the gap, with the wider defence measure being almost a quarter greater than manufacturing and about 20% greater than the all economy pay level.

Figure 5.2: Wage premium by industrial sector for full time employees



Wider Defence is a weighted average across industry medians: Automotive (SIC 291), Aerospace (303), Shipbuilding (301), Military Fighting Vehicles (304) and Manufacture of weapons and ammunition (254). SIC 291, 301 and 303 will include employees working in businesses largely focused on civilian and military. Source is calculations from published ASHE, annual, median, full-time pay estimates by SIC.

Figure 5.2 focuses on the defence premium over manufacturing at a more disaggregated level for the wider defence industries. It separates out the premium seen in 2004-2011 and the premium seen in 2012-14 and indicates the rise has been most pronounced in the automotive, ship building and aerospace industries. The sample size in ASHE for the weapons and military vehicles industry is quite small, but the premium has declined here. The other observation is that, in percentage terms, the premium rise is stable, so a large part of widening gap in the top panel is the general wage increases acting on an existing wage premium. This highlights that the wage premium is persistent.

However, there are some caveats to whether this indicates a premium associated with defence related jobs. Firstly, the businesses that are identified in these industries are a mix of those selling to both defence and non-defence purchasers. A second aspect identified by looking at defence businesses individually is that they are in industries beyond the manufacturing ones identified above.

The rest of this chapter uses the work to identifying defence businesses to focus on jobs in defence. Rather than using SIC codes, the jobs analysed are identified by whether the employer sales are largely to defence or marketed to defence departments.

Occupations and Pay in Defence

After linking the defence businesses identified in chapter 3 to the 2012 Annual Survey of Hours and Earnings, 832 full-time jobs are found. This is about 0.7% all full-time jobs covered by ASHE. In responding to the Annual Survey of Hours and Earnings, employers are asked about the occupation of each job. Table 5.2 presents the occupations which appear in the defence businesses and the wider ASHE sample. The results for 2013 and 2014 are similar, indicated in the annex.

The body of the table lists the occupations where more than ten jobs occur in the defence businesses, while the note to the table indicates the rest of the occupations found in defence businesses. The table also indicates how many jobs ASHE contains that fall in these occupations but are in businesses outside of defence.

The most common occupation is Science, Research, Engineering and Technology Professionals. The 169 jobs in defence businesses also represent 3.1% of all the jobs in SOC 21 found in ASHE. Overall, the table presents a picture of defence roles primarily concentrated in engineering related occupations. As well as the professional science grades, defence has a high number of associate professionals in this field.

Table 5.2 provides data about jobs that are in locations primarily associated with maritime and air defence plants. Only 39 and 67 jobs are categorised as defence marine and defence air businesses. Many occupations have less than 10 jobs reported in ASHE and so fall below the threshold at which ASHE estimates are representative.

The ASHE is primarily a survey of pay. The employers are asked about a reference week for each job and then complete questions about various components of overall pay, including incentive pay, overtime and any pension contributions, alongside the hours worked and the gender and age of the employee. Table 5.3 summarises the pay and hours data for the 2012 full-time jobs. The defence jobs have a higher weekly average pay, with those jobs located near aviation -related plants having a higher pay rate.

Table 5.3 appears to present evidence of a premium in weekly gross pay for defence jobs. Defence jobs have a weekly gross pay of £700, about £118 greater than all jobs in ASHE. However, it is very unlikely to be an accurate estimate of a wage premium because the 832 defence jobs involve individuals that differ from the wider ASHE sample. Potentially, the entire pay difference could reflect, not the fact that the employers are involved in defence, but just that defence tends to have jobs requiring higher skilled or experienced employees. Were these individuals to move out of the defence sector, it may be that the individuals would find, on average, higher paid jobs.

Table 5.2: ASHE Full-Time Defence and non-Defence Jobs by Occupation, 2012

SOC	Description	Defence	Of which:		All jobs	Defence jobs
			Marine	Air		
11	Corporate Managers And Directors	57	<10	<10	6,768	0.8%
21	Science, Research, Engineering And Technology Professionals	169	<10	12	5,379	3.1%
24	Business, Media And Public Service Professionals	39	<10	<10	4,867	0.8%
25		19	<10	<10	1,100	1.7%
31	Science, Eng'ing & Tech Ass Prof'nals	71	<10	<10	3,480	2.0%
35	Business And Public Service Associate Professionals	63	<10	<10	7,892	0.8%
36		10	<10	<10	2,217	0.5%
41	Administrative Occupations	43	<10	0	7,702	0.6%
42	Secretarial And Related Occupations	41	<10	<10	8,515	0.5%
52	Skilled Metal, Elec'l/Electronic Trades	133	11	20	5,095	2.6%
53	Skilled Construction & Building Trades	11	<10	<10	2,015	0.5%
81	Process, Plant & Machine Operatives	74	<10	<10	4,776	1.5%
82	Transport Drivers And Operatives	20	0	0	4,647	0.4%
91	Elementary Trades, Administration, Service And Related Occupations	13	0	0	2,532	0.5%
93		24	<10	<10	5,721	0.4%
All	All Occupations	832	39	67	117,039	0.7%

Occupations where fewer than 10 defence jobs in ASHE: Other Managers And Proprietors (SOC 12), Other Managers And Proprietors (13), Health Professionals (22), Teaching And Educational Professionals (23), Protective Service Occupations (33), Culture, Media And Sports Occupations (34), Textiles, Printing And Other Skilled Trades (54), Caring Personal Service Occupations (61), Leisure, Travel And Related Personal Service Occupations (62), Sales Occupations (71), Customer Service Occupations (72) and Elementary Administration And Service Occupations (92). For Marine and Air jobs, <10 indicates fewer than 10 jobs in ASHE. Marine and Air jobs have been identified by linking job location to the location of major marine/aerospace plants.

Table 5.2 gives an indication of the differences between the jobs in defence and those outside of defence. Occupations related to science and engineering are more common in businesses operating in defence. Occupations, however, are a blunt indicator of skills and experience giving only a qualitative understanding of the role. Table 5.4 offers some evidence about the skills profile of defence jobs.

The US Department for Labor has sought to define occupations in terms of the skills and experience employers expect in those filling the jobs. The Occupational Network (O*NET) conducts surveys of employers asking them to identify the occupations that are common in their businesses and then to score the importance of different skills. For each occupation, the O*NET work provides a score on around fifty categories of skills and experience for all SOC codes. For this study, the scores have been distilled into nineteen composite indicators using factor analysis. Average scores are tabulated in table 5.4 for all the jobs in ASHE, the defence jobs in ASHE and, of these, those located in maritime and aviation employment centres. A higher score means that a certain attribute is more important, while a smaller/more negative

score indicates that it is less important. The description for each factor indicators how each is a composite across a range of different skills/experiences. Some are relatively unique, such as "Physics", but most cover a mix of qualities.

Table 5.3: Defence and non-Defence Weekly Pay Averages for 2012

			Different pay measures drawing from ASHE		
	Number of jobs	**Weekly hours**	**Gross Pay**	**Basic Pay**	**Gross excl Overtime**
Defence jobs	**832**	**39.1**	**£700.92**	**£630.60**	**£669.92**
Of which: Maritime	39	39.6	£698.09	£598.97	£636.04
Of which: Aviation	67	38.5	£742.84	£631.54	£706.78
ALL JOBS	117,039	39.1	£581.67	£538.36	£565.29

The factors are split into three classes: skills, activities and knowledge. These originate from the O*NET work. Further, the order in the table of each factor is by importance of the factor. So, the "People, Systems and Operations" factor explains most of the difference in employers' views on the skills needed by each occupation. Going down the factors, these become less important.

The statistical analysis to distil the indicators means that each is centred around zero for the analysis of all jobs in ASHE. This means that the "All jobs" column has some factors that score positively, some negatively. A first result to note is that the defence jobs are generally better skilled than all ASHE jobs. A positive factor score across (nearly) all the factors suggests that the occupations in defence jobs were associated with high scores from the employers surveyed for O*NET.

Table 5.4: Average skills profile of jobs using O*NET survey				
Factor Description	**All jobs**	**Defence Jobs**	**Maritime Jobs**	**Aviation Jobs**
Skills variables				
People, Systems and Operations	0.16	0.07	0.01	0.36
Materials, Equipment & Technical	-0.19	0.50	0.60	0.80
Programming and equipment	-.0.04	0.75	0.48	0.82
Coordination and Persuasion	0.06	0.28	0.36	0.21
Active learning skills	0.05	0.42	0.19	0.65
Activities variables				
Analysing, processing information, consulting, advising	0.00	0.16	0.22	0.27
Problem solving, negotiating, control, planning & prioritising	0.00	0.16	0.22	0.27
Handling, inspecting objects, machines and vehicles, coordinating people	0.16	0.55	0.29	0.80
Monitoring processes, materials and surroundings and selling and influencing	-0.17	0.30	0.50	0.50
Coaching people, inspecting equipment & structures and selling & influencing	0.18	0.54	0.52	-0.48
Knowledge variables				
Humanities, Law, Education and Chemistry	-0.07	-0.01	0.11	0.03
Science, Econ, Computer Languages, Arts & Geography	0.08	0.08	1.12	1.01
Engineering, Education, Public safety, Food production	-0.11	0.77	0.13	0.23
Telecom, Mechanical, Personnel and human resources	0.15	0.15	0.06	0.62
Transportation, Philosophy and Theology	0.13	0.51	0.07	-0.08
Psychology, Biology, Sociology and Anthropology	0.00	0.10	0.21	-0.37
Clerical, Therapy and counselling	-0.08	0.28	0.45	-0.28
Mathematics knowledge	-0.07	0.17	0.48	-0.41
Physics knowledge	-0.18	0.31	0.00	0.00

Generally, defence jobs are in occupations judged to require high levels of skills, experience and knowledge. While the jobs located in maritime and aviation focused employment centres also have high levels, they are generally similar in the mix to the defence. Overall, this suggests that any comparison of defence pay with the wider economy average in terms of pay would miss the fact that these jobs are likely to need to pay at a higher rate to attract the higher skills needed than the average job.

Table 5.5 indicates the geographical spread of defence jobs. A notable feature is that there are few defence jobs located in London. Any London-associated premium usually needs some specific modelling, because of the different labour market conditions observed in the capital. This analysis has used a simple approach (of using a London dummy) to control for jobs that

are in London, both in the defence firms and those used to compare pay with defence jobs. While there are few jobs in London, the concentration in the Southeast should be noted. London's wage impact spreads into the Southeast, so that the defence jobs here attract some wage premium due to location.

Table 5.5: ASHE Full-Time Defence and non-Defence Jobs by Region, 2012

Region Ref	Description	Defence	Of which:		All jobs	Defence jobs
			Maritime	Aviation		
9	South East	219	**	0	15,746	1.4%
2	North West	137	23	21	12,996	1.1%
6	South West	108	**	0	9,583	1.1%
5	West Midlands	64	0	0	10,403	0.6%
4	East Midlands	53	0	0	8,524	0.6%
7	East	52	0	**	10,432	0.5%
8	London	36	0	0	18,960	0.2%
3	Yorks & Humber	25	0	**	9,803	0.3%
1	North East	17	0	0	4,616	0.4%
	England	711			101,063	0.7%
10	Wales	48	36	36	5,244	0.9%
11	Scotland	73	0	0	10,732	0.7%

There is some evidence of jobs being concentrated in particular locations, related to the location of large military establishments. This may be problematic, in that ensuring jobs are comparable to the defence jobs may not be easy if the defence jobs dominate a geographical labour market. However, the table indicates defence jobs are spread across Great Britain, somewhat ameliorating this.

Evidence of Wage Premium from Job Switchers

A feature of the ASHE is that it maintains the same individuals in each year of the survey. The approach taken by ONS is to contact the employers of individuals with a National Insurance number that ends in two specific digits. This means that, if the individual moves from one employer to another, that fact is retrieved if it is caught in two successive ASHE waves.

The change in job of an individual has a useful statistical property. Except for the additional year of experience, the job holder maintains all his/her characteristics. As has been noted before, a problem for analysis of the wage premium is that the individual characteristics, many unobserved in the data, may be a significant determinant of any premium. However, focusing on switchers can guarantee characteristics are the same except for the feature of interest: the individual working for a defence business. Also, those entering defence businesses from outside can be compared with the flow in the opposite direction. This allows some control for the fact of moving job being correlated with stronger motivation.

The ASHE data was organised to look at individuals over two years. This meant some individuals and their jobs had to be removed as observations in successive years were not

present. Where someone entering a defence job was not employed in the previous year – they may have been studying – or were not included in ASHE – serving in the Armed Forces for example – then their subsequent appearance in ASHE on joining a defence business could not be used. There would be no evidence of their earlier pay. Equally, many individuals who were in a defence business one year but not in that business in the following year could not be tracked. This may reflect a retirement or some other departure from employment.

The analysis was initially undertaken for the 2012-14 period, but sample sizes for those switching in and out of defence jobs were too small for robust analysis. ASHE has been undertaken for many decades, so offering a way to increase the sample size. However, going back over time has one limitation. The identification of business as defence was undertaken in 2016 and becomes less precise going back in time. Hence, the 2009-14 period was used, allowing analysis of five periods of job change from 2009-10 to 2013-14.

Between 2009 and 2014, there were 153 individuals that moved into defence businesses from non-defence businesses and about the same moving the other way. The move to defence businesses was accompanied by an average pay rise of 10%, while the moves out of defence a 5% pay rise. A problem associated with each of these statistics is that variation is high. However, this difference is significant at 5% confidence level: moving jobs does increase pay but the pay increase is significantly higher for those moving into defence when compared to those moving out.

Table 5.6: Evidence of pay changes for those switching from and to defence jobs, 2009-14

Pay change as individuals…			
…Take up jobs in defence businesses	+10.22%	Significant at 1%	Difference is +4.79%
…Leave jobs in defence businesses	+5.43%	Not significant at 10%	
…Stay in defence jobs	+3.49%	Base pay increase	F(1,3693) = 4.9, significant at 5%

Note: Increase in hourly wage rate for full-time employees in defence jobs plus those exiting defence. Significance tests for whether pay increases for movers different from stayers and secondly whether the rise for those entering jobs in defence significantly higher than those leaving defence businesses.

Table 5.6 summarises the pay changes seen in the subsample of people who move into defence jobs from outside defence and those that move the other way. It also looks at those that stay in defence. It presents evidence of a pay premium in defence, indicating that those entering jobs in defence business received pay rise of 4.8 per cent greater than those moving out of those businesses. This difference is significant at 5 percent confidence.

Table 5.6 indicates also that – while those staying in defence get an annual pay increase of 3.5% - those moving into defence jobs see a 10% pay increase. This is significant (at 1%). Those moving the other way, into defence from outside, only see a 5.4% pay rise, which is not statistically different to the annual pay increase in defence jobs.

Determinants of the Wage Premium

Since Mumford and Smith (2004), research has adopted the human capital model as the theoretical basis for the earnings function (an extensive recent survey is Chiswick, 2003). At the employee level, it is assumed that wages increase with measures of accumulated skills such as education, work experience, and training. Further, demographic variables and occupation- and workplace-specific effects are used. The overlaps between these categories mean that, in aggregate, a comprehensive list of variables measuring the relative productivity of workers can be compiled.

Wages are modelled to be correlated to the skills and experience associated with the individual. A problem is that ASHE does not contain the skills of individuals, as the survey does not contact the individuals directly. However, the occupation code, linked to O*NET as it asks about the skills related to an occupation and to the Employer Skills Survey about the difficulty to fill occupations, has meant some skill-related variables have been created.

Measures of work experience are usually assumed to be positively related to wages via the ability to acquire skills over the period the employee has spent working. Typically, studies do not have data on the history of actual lifetime work experience across firms for individuals. Instead proxies are provided, the most common of which is potential experience: the age of the individual.

The study includes some further job characteristics, focusing on the full-time jobs and then including the hours worked in estimation. Finally, the demographic information in ASHE includes the gender of the employee.

Table 5.7 presents results for 2014. It indicates the regression results from modelling the wage equation using interaction terms. Such regressions underpin the driver analysis for this study and the table also indicates the results for 2014, as “Contribution to premium”.

The estimation for all jobs indicates the basic determinants of wages from the 106,609 observations. Wages are positively related to age of the employee and where the employee is male. It is also positively related to the size and capital intensity of the employer and whether the business is in London or the Southeast.

An important part of this modelling is to look at the interaction between characteristics and the fact of being a defence job. In Table 5.7, the focus for the interaction is on the age and gender of the jobholder and the skills and extent of shortage in the occupations. Because of the range of skills modelled, the aggregate impact across the different skills factors is calculated. The table also presents the mean of all variables, both for the whole sample of jobs (on the left-hand side panel) and the defence jobs only (on the right-hand side panel).

Table 5.7: Determinants of the wage premium, 2014

	Contribution to premium	Estimates for all jobs			Interaction term		
	ß	ß	s.e	Mean	ß	s.e	Mean
Constant	0.045	5.340	0.010	1.000	0.045	0.063	1.000
Prime	0.013	0.045	0.034	0.002	n/a		
Age	-0.013	0.006	0.000	40.90	0.00	0.00	43.63
Gender	-0.010	-0.135	0.003	0.41	-0.06	0.04	0.17
Shortage occupation (=1)	0.04	0.02	0.01	0.39	0.09	0.05	0.44
Skills proxies total	-0.002	TOTAL OVER ALL SKILLS			TOTAL OVER ALL SKILLS		
People, Systems and Operations	-0.011	0.034	0.004	0.16	-0.16	0.06	0.07
Materials, Equipment & Technical	0.026	0.068	0.005	-0.19	0.05	0.06	0.48
Programming and equipment	-0.119	-0.008	0.004	-0.03	-0.16	0.05	0.72
Coordination and Persuasion	-0.005	0.019	0.002	0.06	-0.02	0.03	0.27
Active learning skills	-0.005	-0.017	0.002	0.06	-0.01	0.02	0.40
Analysing, processing information, consulting, advising	0.028	0.052	0.003	0.01	0.18	0.04	0.15
Problem solving, negotiating, control, planning & prioritising	0.062	0.148	0.004	0.16	0.12	0.05	0.53
Handling, inspecting objects, machines and vehicles, coordinating people	-0.041	-0.054	0.006	-0.17	-0.14	0.07	0.29
Monitoring processes, materials and surroundings and selling & influencing	-0.020	-0.109	0.003	0.18	0.04	0.04	-0.52
Coaching people, inspecting equipment & structures and selling & influencing	-0.001	-0.028	0.002	-0.07	0.09	0.03	-0.01
Humanities, Law, Education and Chemistry	0.009	0.062	0.003	0.08	-0.11	0.04	-0.08
Science, Econ, Computer Languages, Arts & Geography	0.039	-0.013	0.003	-0.10	0.05	0.04	0.75
Engineering, Education, Public safety, Food production	-0.006	0.105	0.003	0.15	-0.04	0.04	0.15
Telecom, Mechanical, Personnel and human resources	0.017	0.010	0.003	0.14	0.04	0.04	0.49
Transportation, Philosophy and Theology	0.005	-0.021	0.002	0.00	-0.05	0.03	-0.10
Psychology, Biology, Sociology and Anthropology	0.017	0.064	0.002	-0.08	-0.06	0.03	-0.27
Clerical, Therapy and counselling	0.004	0.025	0.002	-0.08	-0.03	0.02	-0.17

5. Wage Premium Estimates

	Contribution to premium	Estimates for all jobs			Interaction term		
	ß	ß	s.e	Mean	ß	s.e	Mean
Mathematics knowledge	0.002	0.014	0.002	-0.18	-0.01	0.03	-0.30
Physics knowledge	-0.002	-0.055	0.002	-0.01	0.03	0.03	-0.06
Total hours		0.01	0.00	39.17	n/a		
Capital exp (£'00/employee)		0.00	0.00	3.29	n/a		
Apprentice (=1)		-0.30	0.01	0.01	n/a		
Manufacturing (=1)		0.06	0.00	0.12	n/a		
Private sector (=1)		-0.03	0.00	0.71	n/a		
Employment (00.000)		0.00	0.00	0.00	n/a		
Log Employment		0.02	0.00	0.00	n/a		
Size (Large=1)		-0.01	0.00	0.61	n/a		
London		0.25	0.00	0.16	n/a		
Southeast		0.07	0.00	0.14	n/a		
Number of obs.	106,609	R-Squared		0.4977	Adj R-Squared		0.4972

Contribution to the premium is calculated by multiplying the interaction co-efficient by the mean of the characteristic for the defence firms.

The contribution to the premium column estimates the contribution to the wage premium of the characteristic of the average defence job when compared to all jobs. The two mean columns show the difference between defence jobs and all jobs in ASHE: those in defence jobs are nearly 44 years old, three years older than all jobholders.

The table gives the premium for defence jobs over comparable jobs and then attributes the premium to the interaction of being a defence business and the different aspects of the job. For example, there is a premium for shortage occupations and this occurs across different sectors: where employers identify a shortage occupation, this correlates with a wage premium. However, in defence jobs this effect is enhanced, contributing about 4% of the overall 7% premium in the table. Another feature identified in the table is that the pay of employees in the defence firms identified as primes – these businesses lead large contracts for the Ministry of Defence – contributes about one per cent to the premium.

Overall, the disaggregation highlights what is driving the premium. Some of the premium is associated with the businesses that are defence primes having higher wage levels. This means implicitly that the supply chain and lower tier defence businesses have lower wage premium. The effect is not very large, but may suggest that the more competitive parts of the defence sector have a lower wage premium.

BOX: Statistical estimation of a wage premium

The most straightforward analysis of a defence premium is to run a regression of the (log) gross pay, *w,* for all jobs on the characteristics of the job, *X*, and with a dummy variable to identify those in defence:

$$w_i = \alpha + X_i\beta + D_i\gamma + \varepsilon_i$$

The estimations presented extract the wage premium but this can be further disaggregated. To achieve this disaggregation, the model is augmented using interaction terms on the characteristics variable:

$$w_i = \alpha + X_i\beta + D_iX_i\gamma' + \varepsilon_i$$

To estimate the effect of the different characteristics in the estimation of the defence wage level, the difference between the two models is used. An account can be generated for each of the variables using the average values taken in the defence jobs.

There are occupations that employers say have shortages and this is highly correlated with the wage premium, contributing about half. This suggests that the labour supply constraints in specialisms needed for defence production are causing businesses to pay a higher wage rate. This is more in line with a productivity argument for the defence wage premium, with businesses offering higher wages to attract the labour needed.

The individual skills – providing the bulk of the results in the table – do not in themselves correlate with the premium. However, the table can be used to demonstrate how important skills are in determining the wage rate for a defence job. The mean skill scores for the defence jobs is far higher than those the wider workforce and this skills base means the average defence job is paid about 15% more than the wider workforce. Earlier comparisons of the pay in defence compared to the whole economy indicate that this would represent about two thirds of the pay differential between defence jobs and other jobs. Skills do matter in setting pay, because the level is higher for defence jobs. However, the defence sector does not pay a premium for individual skills, as the reward for skills is similar to that found in other industries.

6. Conclusions

There may be an economic rationale for wage premiums in the defence sector: The defence industry can capture economic rents, partly because many of the firms are specialists in their fields, customising products to the needs of the UK Ministry of Defence. Efficiency wages could also play a role in wage setting in the defence sector. As firms are highly specialised, workers acquire sector-specific skills, that can also be valuable in adjacent sectors, such as related civil sectors. To reduce turnover and reduce the loss of intellectual property, firms may choose to pay higher wages. Lastly, there could also be aspects related to the defence sector that workers would want to be compensated for or for which they merit a premium. This could include, for example, the need for security clearance and the costs associated with the confidentiality of the work.

This study uses a rich dataset about one percent of jobs in Great Britain, including those in defence businesses. The ONS Annual Survey of Hours and Earnings provides the occupation, the pay and the hours of work for around 120,000 full-time jobs. The survey can also be linked to the employer business and so identify any jobs in the businesses considered to be supplying defence products. This means ASHE – when combined with some other datasets – can be used to estimate any wage premium associated with jobs in defence when compared with those outside of defence.

In 2012, 832 jobs were identified. These defence jobs have a weekly gross pay of £700, about £118 greater than all jobs in ASHE. The jobs are more likely to be in occupations “Science, Research Engineering and technical Professionals”, “Science, Research Engineering and technical Associates”, “Skilled Metal, Electrical and Electronic Trades”, “Process, Plant and Machine Operatives: than the wider ASHE sample. These occupations mean that the jobs are associated with skills and knowledge that are focused on science engineering. Using data about the skills and experience associated with these occupations, the study has sought control any premium because the defence jobs are likely to involve individuals that differ from the wider ASHE sample.

The data on individual jobs has been linked to details about the employer and the skills and experience associated with the occupation of each job. The wage premium in jobs in businesses identified as “defence” is estimated. Two results are found: each estimation supports a premium of around 5-12% for defence jobs. Further, there is no additional premium for jobs located in centres of maritime employment (such as naval dockyards), while there is one for aviation related employment. Finally, a more restricted definition, focusing on businesses that may be considered prime suppliers (or Tier 1/2) has a same level.

A concern in attributing wage differences that the entire pay difference could reflect, not the fact that the employers are involved in defence related work, but just that defence tends to have jobs requiring higher skilled or experienced employees. Were these individuals to move out of the defence sector, it may be that the individuals would find, on average, higher paid jobs.

Much of this study has sought to extract from the wage premium the effect of any difference due to employees’ skills and experience. The study finds that just over half the defence premium is explained because of the correlation between the occupations that defence recruits and occupations that employers consider as having shortages.

Further Work

There remain some gaps in the research presented and some aspects where further work may enlarge the understanding of the economic value of defence jobs.

The ASHE survey has limitations. Its sample, while relatively high in comparison to labour force surveys, does become too small when analysing local labour markets and focusing specific industries. In this study, the focus has stayed on the defence sector and not delved deeply into the defence industry in parts of the UK. However, there is considerable interest in clusters of defence activity, especially because government policy has sometimes focused on such clusters. To look at the defence sector at this detailed level alternative data sources would be needed.

The study could not consider the pay of specific professions or categories of employee. For the former, policy is particularly focused on whether specialist engineering roles are being filled and, if not, how the gaps that emerge might be managed or ameliorated. This issue was raised in the interviews with defence stakeholders. Equally, there is considerable interest in the careers of former service personnel in the defence sector.

To track such groups of employees, the empirical approaches used in this study are probably appropriate, however specific data will need to be collected. The possible sources for more detailed analysis are developing. Administrative data about employment are increasingly being used for productivity related analysis, such as returns made to HM Revenue and Customs. Also, as the MOD procures, information is gathered about the employment associated with large contracts. These sources are complex and may also need to supplemented by specific data collections.

Annex A: Literature Review

In economic models, workers are paid the marginal product of their labour in a perfectly competitive market. Therefore, workers with equal productivity are expected to earn the same wage. Nevertheless, it is a long-established fact that wages vary substantially by industry, region, gender and other factors such as unionisation or firm size. There exists a literature to explain, or "explain away", these apparent wage premiums. Two dominant strands of theories have emerged:

- Difference in pay are due to differences in unmeasured ability: This theory maintains that workers are paid according to their marginal product, but that differences arise because not all aspects of worker productivity can be observed. Studies in this tradition usually rely on difference-in-difference or fixed effects regressions to control for unmeasured heterogeneity across workers.
- True wage differences do exist and are due to market imperfections: This literature asserts that even when controlling for unobservable characteristics, wage premiums do not fully disappear. There are then several theories that explain the persistence of wage differences, such as efficiency wages, rent sharing, or compensation for undesirable aspects of the work.

Difference in Pay due to Unmeasured Ability

The main challenge in estimating the effect of ability is many aspects in a sample of workers remain unmeasured and so it is difficult estimating a wage premium controlling for these unmeasured ability drivers. Often this challenge is met by using a panel of workers switching employer that allows controlling for worker fixed effects. Alternatively, there are sometimes natural experiments, such as the closing of a plant, that control for any endogeneity of the switching decision. In the following, we present types of wage premiums that have been investigated in this fashion.

One of the most frequently investigated issues is the existence of a public sector wage premium. For the UK, Disney and Gosling have looked at this issue from two different angles. First, Disney and Gosling (1998) compare pay distributions between the public and private sectors. After controlling for age and education, they found large differences. Women and those with intermediate education did best in the public sector. The wage premium was shrinking over the study period (1983-1995) when controlling for occupational composition of both sectors.

However, not everybody benefited from the premium: men with higher education degrees and women without qualifications were worse off in the public sector. Using panel and quintile regressions with individual fixed effects, the authors also looked at individuals moving between the public and the private sector. They find a positive effect of moving to the public sector. However, this is most likely due to penalties when moving in the other direction, from public to private, due to public-sector specific skills previously acquired. All of these results can be explained by the relative quality of graduates: those with higher grades tend to go to the private sector. Furthermore, higher rates of unionisation tend to reduce the variance of wages in the public sector, benefitting women and those with intermediate skills.

In a follow-up study, Disney and Gosling (2003) examine privatisation in the British economy. This followed the impact on wages when workers moved from the public to the private sector. Because the movement into the public sector was irrespective of workers tastes and productivity, this eliminates the problem of self-selection. Still, they confirm the earlier finding that women earn a premium in the public sector.

From a similar starting point, Bryson (2002) tries to determine the existence of a union membership wage premium. Traditionally, union members earn more than non-union members, but taking union membership as deterministic of higher wages is hard to square with the fact that union membership has been on the decline. To control for most other factors determining wages, Bryson therefore uses propensity score matching (PSM) to form a control group of non-unionised workers with similar characteristics to their unionised peers. Unfortunately, the author had only one cross-section available, from the 1998 WERS, and was therefore not able to observe differences over time. Nevertheless, controlling for other observable factors through PSM significantly reduced the size of the trade union premium. The premium only remained statistically significant in covered workplaces, where union members tended to earn 6.4 per cent more than their non-unionised peers.

Wage premiums are also associated with employer characteristics. Trotske (1994) uses the US Worker-Establishment Characteristics Database which contains linked employer-employee data, to study if characteristics of the employer are associated with a wage premium. He finds a positive correlation between skills of managers, skills of employees, and the size of the plant, but the wage premium disappeared after accounting for capital stock. These findings, obtained from standard wage regressions and re-weighting exercises to account for differences in work force compositions, are therefore consistent with a production function where labour input is in the context of complementary capital.

A similar observation to the employer-characteristics premium is underlying the search for a foreign-ownership premium, studied by Girma and Goerg (2006). They use acquisitions of UK firms by foreign companies as a natural experiment to investigate the causal effect of foreign ownership on wages of skilled and unskilled workers. To do so, the authors apply difference-in-difference estimation on a sample generated using PSM from the ONS Annual Respondents Database (1980-1994). Assuming that firms do not change in the short run after an acquisition all effects on wages are attributed to the change in ownership. The authors find that the effect on wages depends on the skill level of employees, industry, and the home country of the acquirer (positive effect from acquisition by US company, but none from EU companies). They are unable to explain what drives these changes in wages. However, industrial organization theory postulates that multinationals are able to pay higher wages because they own firm specific assets which increases the marginal productivity of workers. Therefore, this would also not comprise a true premium.

True Pay Premiums

Gibbons and Katz (1989) note all of these estimations suffer from one flaw, however: they assume that compensation for unmeasured ability are uniform across industries. Once this assumption is relaxed, it is no longer the case that differencing will be able to account for unmeasured ability. Rather, they explain that there will be a matching of workers' abilities to industries, so that a change in employer and the very industry they work for is endogenous. To control for this endogeneity, they use the natural experiment of plant closures, so that the search for new employment opportunities is no longer endogenous. They also run first-differences wage regressions to estimate the effect of industry switching on displaced workers' wages. They also determine the effect of the pre-displacement industry on post-displacement

earnings. From these regressions, they conclude that unmeasured ability cannot account for persistent inter-industry wage differences. Instead, two findings point to the importance of rent sharing: the highly negative correlation between wage premiums and quit rates, as well as the high correlation of wage differentials between occupations within one industry (e.g. secretaries and assembly line workers earning similar premiums despite performing very different tasks).

In a more recent paper, Abowd et al. (2013) investigate the issue of rent sharing further. They explain inter-industry wage differences by decomposing them into employer and employee effects. In their model, the differential due to individual heterogeneity depends on workers' opportunity wage rates, and the differential due to employer heterogeneity depends on product market quasi-rents (monopoly/ oligopoly rents) and relative bargaining power of workers. The employer effect is again disaggregated into pure firm and pure industry effects. Furthermore, time-varying covariates are allowed to have an effect on wages. They estimate this model using longitudinally linked employer and employee data from the US and France. It turns out that quasi-rents per worker account for large proportions of the wage premium. This gives further credibility to Gibbons and Katz' point that wage premiums are real and persistent.

Another factor that could account for wage premiums are efficiency wages. This theory contends that it is efficient to pay workers more than their marginal product to discourage them from shirking and reduce employee turnover. The information asymmetry overcome in this way increases plant productivity by more than enough to offset higher wage costs. If information asymmetries differ across industries, this could explain why some employers choose to pay efficiency wages while others stick with lower wage rates. Cappelli and Chauvin (1991) test the effect of wage premiums on shirking by exploiting variations in local wage premiums across plants. All plants in their sample belonged to the same firm, were covered by the same union and collective bargaining arrangements, and workers performed similar jobs. Personnel and disciplinary policies were also centrally coordinated. However, based on local labour markets (i.e. the wages workers could expect to earn if they were dismissed) wage premiums differed across plants. Estimating the effect of the local wage premium on the rate of worker dismissal for disciplinary reasons, the authors find a negative effect of the premium on shirking. Hence, efficiency wages seem to be able to overcome information asymmetries and induce workers to exert more effort. However, the authors stress that they did not attempt to estimate the actual efficiency of the wages, i.e. whether the pay premiums paid for themselves through higher productivity.

Annex B: Estimating the Wage Premium

The main source of data used in the approach to estimate wage premiums is the Annual Survey of Hours and Earnings (ASHE). This is the Office for National Statistics' (ONS) principal source for earnings estimates, collected in April of each year, and uses data on 181,000 employees, of which about 120,000 are full-time. To estimate the wage premium, there were three methodological steps:

- Businesses in defence were identified (chapter 3 describes this) and matched to surveys in the ONS Virtual Microdata Lab, primarily ASHE
- Each job in ASHE was linked using occupational classification to skills and experience variables
- Regression methods were used on the dataset to estimate wage premiums.

This annex describes the data for skills/experience. It then presents the detail of the estimation.

Skills in Defence and non-Defence Jobs

ASHE provides the wage rate, hours worked and other characteristics for a large sample of jobs. There are other factors which should be considered when estimating a possible wage premium in the defence sector: skill level of employees, specific activities performed on the job and knowledge required for the job. For example, it is possible that employers in the defence industry seek employees who have a higher level of skills that are in short supply, or specific activities and/or knowledge which may be scarce. A shortage of specific skills or knowledge could be putting an upward pressure on wages.

Skills by Occupations

The main variable in ASHE that defines the type of job is occupation, using standard occupational classification revision 2010. This coding can then be linked to the US-based Occupational Information Network's (O*NET) comprehensive source of information on skills, activities and knowledge for occupations. The O*NET database provides information on the required skills using around 250 measures of skills, abilities, work activities, training, work context and job characteristics for each of around 1,000 different US occupations (based on a modified version of the US Standard Occupational Classification). The data is gathered from employers and employees through standardised survey questionnaires and is further assessed by professional job analysts. A first step to making the dataset usable in this project was to match O*NET SOC codes to UK SOC codes. In a second step, variables are condensed into factors to make them usable in regression analysis.

Recently, the O*NET system has updated its US SOC classification to a new O*NET-SOC2010 version. The O*NET-SOC taxonomy is now aligned with the US standard occupational classification, 2010 revision. As a result, there is potentially new data, including skills and abilities, which can be matched. The information is available for both the levels of skills or abilities required and the importance of these skills/abilities for the occupation concerned.

During the present analysis, it became apparent that there was considerable difficulty in getting unambiguous, one-to-one matches between O*NET and UK occupations. Direct matching of O*NET SOC to UK SOC was not possible. Instead, the approach was to first match the O*NET SOC codes to the international SOC (ISCO) codes, using look-up files provided by O*NET and the Bureau of Labor Statistics (BLS), and then manually match the UK SOC codes to international SOC codes. As there are more occupational titles in the O*NET database than in the UK SOC, some UK occupations are mapped to more than one equivalent US occupation. In some cases, however, there are direct single matches. Also, it should be noted that the look-up file (matching ISCO codes to UK SOC) contains 145 ISCO codes that were not matched to the UK SOC.

O*NET data is very rich for different occupations: it defines 30-40 skills, activities and knowledge for each occupation, in terms of the level needed and its importance. For example, for a secretary, basic IT skills are very important, but the level required is only intermediate, whereas for a web designer, both level and importance are high. The quantification is based on survey results about the percentage of employees in a given occupation who have a given level of experience, education or training. For example, the value for “education – level 6” for electrical engineers is 70, meaning 70% of electrical engineers require a bachelor’s degree.

Because of the large number of skills, activities and knowledge variables available in O*NET it is difficult to conduct a meaningful analysis without first reducing these variables to a smaller number. Hence, factor analysis was used to reduce variables to several meaningful factors. The factor analysis assigns to each variable a factor loading, indicating its importance for a certain factor variable. The values for different SOC codes are generated by multiplying the value for each variable by its factor loading and summing up across variables. Because factor loadings can be negative, some SOC codes have negative scores for some factor variables.

Factor analysis aggregates and normalises the data, reducing the data to a more manageable size by combining variables that are highly correlated. This distils the rich O*NET data into an alternative summary of skills, activities and knowledge by nineteen factors, extracted from the results of the principal component analysis. A key advantage is also that the resulting factors are rendered orthogonal, such that any problems of multicollinearity between the skills variables, if they were used as individual regression inputs, is overcome.

To test the validity of the analysis, Bartlett’s test of sphericity was conducted. In this case, the values allowed the null hypothesis that these variables are not correlated with the population to be rejected, confirming the validity of the principal component analysis. Kaiser-Meyer-Olkin’s (KMO) test on sampling adequacy, measuring the proportion of variance among variables that may be common variance.

In the final stage, the resulting components were identified by examining the scree plot and using the Kaiser’s criterion of adopting all factors with Eigen value greater than 1. However, it should be noted that the original solution for skills and activities variables was 7 and 6 factors respectively. These variables were reduced to 5 factors each after qualitative inspection of the data to provide more meaningful results. Overall, in distilling the O*NET data into 19 variables, over 80% of the total variance for skills, activities and knowledge was retained.

Shortage Occupations

The 2015 Employer Skills Survey was used for this research to provide a range of variables about the shortages employers had observed in certain occupations. The survey asks 91,000 employers about their vacancies and their experience with difficulties of filling these. Respondents are asked to list some typical jobs they have run recruitments for, whether they

proved hard to fill and – if so – what reasons explained their recruitment problems. Each role that the survey covers is coded to a SOC.

The survey goes beyond skills shortages, asking about business strategies to meet skills gaps such as training plans. However, for this study, the ability to link occupations with evidence about skills shortages was the focus. A range of variables were generated detailing whether occupations exhibited shortages (the proportion of responses that answered there was difficulty in filling a vacancy) and then simple averages about the reasons for failure to fill.

Location of Defence Jobs

ASHE provides the postcode of each job, reflecting the address of the plant at which an employee works. This becomes a very useful variable, with many defence jobs being in businesses that have multiple plants. The ASHE evidence helps to identify both where the job is and, when linked to other data, specific detail about the type of role within defence that the job is associated with.

BIS provided the study with lists of major defence locations, including the name of the company or companies that worked in the locations. The team then reviewed public documents to characterise each location. For major defence projects, this information reveals whether the location is likely to be associated with maritime defence expenditure, procurement that is related to the land environment, or aviation related. A cautious approach to this geo-coding was needed – for example London was ignored given the density of jobs in the capital precludes accuracy.

Estimating the Wage premium using Regression

The most straightforward analysis of a defence premium is to run a regression of the (log) gross pay, w, for all jobs on the characteristics of the job, X, and with a dummy variable to identify those in defence.

$$w_i = \alpha + X_i\beta + D_i\gamma + \varepsilon_i \qquad \text{B1}$$

Table B1 presents the results for 2012-4 for four models. The first two models use a definition of defence jobs that is relatively wide, in that these are suppliers to MOD and businesses that are members of one of the other defence lists. The definition excludes businesses where the sales to MOD were known to be a small portion of total sales. It defines about a thousand jobs as defence. In this definition, the sample of businesses that are located in maritime and aviation centres of employment is sufficiently large to allow a dummy for each of these to be included.

The defence premium is about 10%. This is after controlling for various indicators of firm size, the location of the job and the four-year average of capital expenditure per employee. As well as skills proxies, the estimation includes measures of occupational skills shortages, taken from the Employer Skills Survey. The regression fit is high and the explanatory power of the controls is – as expected – strong.

Table B1.1: Wage premium regression results for 2012

Log gross pay	Defence businesses				Restricted defence businesses			
	ß	SE	ß	SE	ß	SE	ß	SE
Defence businesses (dummy)	0.12	0.02	0.11	0.02	0.14	0.01	0.13	0.02
Maritime defence businesses	0.02	0.07	0.02	0.07				
Aviation defence businesses	0.10	0.06	0.10	0.06				
Age	0.01	0.00	0.01	0.00	0.01	0.00		0.00
Capital exp (£'00/employee)	0.07	0.00	0.06	0.00	0.07	0.00		0.00
Employment	-0.08	0.00	-0.07	0.00	-0.08	0.00		0.00
Size	0.02	0.00	0.02	0.00	0.02	0.00		0.00
London	0.27	0.00	0.27	0.00	0.27	0.00		0.00
Southeast	0.08	0.00	0.08	0.00	0.08	0.00		0.00
Constant	6.07	0.01	5.71	0.01	6.07	0.01		0.01
Skills proxies	Occupation		O*NET		Occupation		O*NET	
Number of obs	109638		102382		109638		102382	
Adj-R2	0.40		0.45		0.40		0.45	

Table B1.2: Wage premium regression results for 2013

Log gross pay	Defence businesses				Restricted defence businesses			
	ß	SE	ß	SE	ß	SE	ß	SE
Defence businesses (dummy)	0.11	0.01	0.09	0.02	0.12	0.02	0.11	0.02
Maritime defence businesses	0.03	0.04	0.04	0.04				
Aviation defence businesses	0.03	0.06	0.04	0.06				
Age	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
Capital exp (£'00/employee)	0.07	0.00	0.06	0.00	2.34	0.09	0.06	0.00
Employment	-0.09	0.00	-0.08	0.00	-0.09	0.00	-0.08	0.00
Size	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00
London	0.26	0.00	0.27	0.00	0.26	0.00	-0.01	0.00
Southeast	0.07	0.00	0.07	0.00	0.07	0.00	0.27	0.00
Constant	6.08	0.01	5.72	0.01	6.07	0.01	5.72	0.01
Skills proxies	Occupation		O*NET		Occupation		O*NET	
Number of obs	111509		104051		111509		*104051*	
Adj-R2	0.41		0.46		0.41		0.46	

In the modelling, two skills proxies are used. The first is relatively crude, using 1-digit occupational code dummies. It is noticeable that when the O*NET factors are used, improving the skills profiling for each job, the defence premium remains similar but lower.

The estimations presented extract the wage premium but this can be further disaggregated. To achieve this disaggregation, equation B1 is compare to a model which uses interaction terms, equation B2, on the characteristics variable.

$$w_i = \alpha + X_i\beta + D_i X_i \gamma' + \varepsilon_i \qquad \text{B2}$$

Table B1.3: Wage premium regression results for 2014

Log gross pay	Defence businesses				Restricted defence businesses			
	ß	SE	ß	SE	ß	SE	ß	SE
Defence businesses (dummy)	0.12	0.02	0.09	0.02	0.15	0.02	0.13	0.02
Maritime defence businesses	0.05	0.05	0.04	0.05				
Aviation defence businesses	0.10	0.04	0.13	0.04				
Age	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
Capital exp (£'00/employee)	0.07	0.00	0.06	0.00	0.07	0.00	0.06	0.00
Employment	-0.10	0.00	-0.07	0.00	-0.10	0.00	-0.07	0.00
Size	0.03	0.00	0.02	0.00	0.03	0.00	0.02	0.00
London	0.25	0.00	0.25	0.00	0.25	0.00	0.25	0.00
Southeast	0.07	0.00	0.07	0.00	0.07	0.00	0.07	0.00
Constant	6.07	0.01	5.71	0.01	6.07	0.01	5.71	0.01
Skills proxies	Occupation		O*NET		Occupation		O*NET	
Number of obs	114195		106609		114195		106609	
Adj-R2	0.41		0.46		0.41		0.46	

Wage Premium in Matched Jobs

To select comparable jobs in the non-defence businesses, propensity score matching (PSM) is used (BIS, 2016 for a full description). A first step is to model the likelihood of a job being in a defence firm, estimating the chance of this using a probit model. The modelling provides a measure called the propensity score, which is used to construct the matched group. A job is selected from the non-defence jobs that has a propensity score closest to each of the jobs in defence businesses (i.e. on the basis of all observed characteristics). "Matching with replacement" is used, meaning that a non-defence job from the wider ASHE pool can be the "nearest neighbour" match for multiple treated businesses (Rosenbaum, 2002).

There are two key assumptions must hold: the conditional independence assumption and the common support assumption. Conditional independence means that there are no unobservable differences between the defence and non-defence jobs after conditioning for the characteristics of each job, so that any systematic differences in wage levels can be attributed to the sector (Imbens 2004, Smith and Todd 2005). The common support assumption requires an overlap in the distribution of covariates between the defence jobs and the non-defence jobs to make matching possible. If this is not the case, then some part of the defence jobs are unique and no match can occur.

The modelling of the propensity score uses a probit model. This is presented in table B2 and indicates that the modelling of defence jobs can identify likelihood quite well. The pseudo R-

squared measures the quality of the fits and, at around 0.27, indicates the modelling explains the data reasonably well. A job in defence tends to be held by an older individual, who is male and the employer is likely to be in manufacturing, with the plants being large and located in the Southeast but not in London. The table does not include the various variables for skills used to model whether a job is in defence. However, results are consistent with other findings, that defence jobs are generally highly skilled.

Once a comparable set of businesses has been constructed, it is straightforward to calculated the average pay for each group and to test whether any difference is significant. The modelling was run for each of the years 2012-4 and table 5.1 provides the results. Analyses was also conducted matching the jobs located in centres of maritime and aviation employment.

Table B2: Probit model for selection into defence

	2012		2013		2014	
	ß	Z-score	ß	Z-score	ß	Z-score
Age	0.00	2.93	0.00	3.53	0.01	4.84
Gender	-0.13	-2.92	-0.13	-3.18	-0.16	-3.71
Total hours	-0.01	-2.00	-0.02	-5.27	-0.01	-2.95
Capital exp (£'00/employee)	0.00	-2.99	-0.01	-4.21	-0.01	-4.30
Manufacturing (=1)	0.87	21.97	0.15	1.75	0.45	3.26
Private sector (=1)	1.32	8.32	0.86	23.15	0.77	21.16
Employment ('00,000)	0.00	-6.83	1.15	10.27	1.12	10.51
Log Employment	0.20	11.51	0.00	-8.11	0.00	-9.50
Size (Large =1)	-0.42	-6.77	0.19	11.12	0.21	11.77
London	-0.23	-3.18	-0.27	-4.51	-0.22	-3.95
Southeast	0.36	8.43	-0.25	-3.73	-0.25	-3.79
Shortage occupation (=1)	-0.04	-0.34	0.29	6.90	0.25	5.92
Constant	-5.03	-21.03	-4.32	-19.46	-4.77	-23.50
Skills proxies	O*NET and ESS		O*NET and ESS		O*NET and ESS	
Number of obs	102382		104051		106609	
Log likelihood	-2953.6		-3296.0		-3404.0	
Pseudo R2	0.27		0.27		0.26	

Balance Tests after Propensity Score Matching

It is important to check the matching quality. Checks firstly look at the average characteristics of the defence jobs and the selected comparable jobs. Table B3 presents results for 2012-4. For 2012, it shows that, while employment was significantly lower in the unmatched ASHE population of 102,379 jobs, the 666 jobs that were matched to the defence jobs had an insignificant difference. There are statistical tests to confirm the two groups are similar. The attention then turns to whether individual jobs are matched to appropriate non-defence jobs in terms of the propensity score. A focus is whether there is an overlap or 'common support' region. The intuition behind common support is that jobs with the same characteristics should have a positive probability of being both a defence job and a non-defence one. The matching is considered unsuccessful if this is not the case (Heckman, LaLonde, and Smith, 1999).

Table B3: PS-tests on matching balance

Category	Variable	2012 Means of samples: Defence Jobs	2012 Means of samples: Non-Defence Jobs	2012 Means of samples: Matched Jobs	2012 Bias in matched sample (%)	2013 Means of samples: Defence Jobs	2013 Means of samples: Non-Defence Jobs	2013 Means of samples: Matched Jobs	2013 Bias in matched sample (%)	2014 Means of samples: Defence Jobs	2014 Means of samples: Non-Defence Jobs	2014 Means of samples: Matched Jobs	2014 Bias in matched sample (%)
Person	Age	43.44	40.74	43.61	-1.50	43.75	40.83	43.12	5.30	44.04	40.76	44.34	-2.50
	Sex	0.18	0.42	0.20	-2.70	0.19	0.42	0.21	-5.30	0.18	0.43	0.17	2.60
	Total hours worked	39.46	39.03	39.36	1.60	38.81	39.02	38.57	4.80	39.31	39.15	39.25	0.90
Firm	Capex past three years	6.45	3.61	6.64	-0.80	6.07	3.26	6.30	-1.90	5.59	3.14	5.47	1.10
	Manufacturing (=1)	0.67	0.11	0.66	3.00	0.67	0.12	0.65	4.30	0.64	0.11	0.66	-6.00
	Private sector (=1)	1.00	0.69	1.00	0.00	0.99	0.69	0.99	1.60	0.99	0.72	0.98	2.40
	Employment	5779.20	15593.00	4851.40	3.3*	5318.20	15160.00	4114.40	4.3**	4335.30	14196.00	4006.20	1.20
	Log Employment	7.11	7.05	6.89	8.60	7.17	7.03	6.93	9.5*	7.08	6.96	6.95	5.50
	Large business (=1)	0.58	0.61	0.54	-4.50	0.63	0.61	0.59	-4.00	0.64	0.61	0.63	-5.60
	London (=1)	0.04	0.17	0.06	-4.50	0.04	0.17	0.05	-4.00	0.05	0.17	0.06	-5.60
	Southeast (=1)	0.27	0.14	0.30	-5.60	0.24	0.14	0.27	-6.80	0.22	0.14	0.24	-5.40
Occupation	Shortage occupation (=1)	0.47	0.39	0.46	4.70	0.47	0.39	0.49	-5.90	0.46	0.39	0.46	0.40
	Hard-to-fill occupation (=1)	1.94	1.26	1.52	9.90	1.91	1.27	2.06	-3.60	1.90	1.25	1.75	3.80
Skills	People, Systems and Operations	-0.04	0.15	-0.06	2.00	0.00	0.15	-0.04	3.90	0.00	0.13	0.00	0.40
	Materials, Equipment & Technical	0.38	-0.21	0.35	3.20	0.37	-0.21	0.34	2.80	0.39	-0.21	0.40	-1.10
	Programming and equipment	0.83	-0.03	0.99	-13.7*	0.86	-0.02	0.97	-8.90	0.84	-0.03	0.89	-3.90
	Coordination and Persuasion	0.25	0.06	0.27	-2.10	0.30	0.06	0.25	5.50	0.30	0.06	0.31	-1.70
	Active learning skills	0.35	0.07	0.00	0.00	0.38	0.07	0.00	0.00	0.38	0.07	0.00	0.00
Activities	People, Systems and Operations	0.03	0.00	0.08	-4.10	0.10	0.00	0.08	2.10	0.12	-0.01	0.15	-2.70
	Materials, Equipment & Technical	0.58	0.16	0.63	-6.00	0.59	0.16	0.59	-0.60	0.58	0.15	0.57	0.10
	Programming and equipment	0.18	-0.20	0.11	6.90	0.17	-0.20	0.14	2.90	0.18	-0.20	0.14	4.00
	Coordination and Persuasion	-0.56	0.16	-0.66	10.50	-0.60	0.16	-0.67	6.80	-0.60	0.17	-0.67	7.50
	Active learning skills	-0.01	-0.07	0.03	-3.20	0.00	-0.08	0.03	-2.70	-0.02	-0.08	-0.03	1.00

Table B3: PS-tests on matching balance (cont.)

Category	Variable	2012 Means of samples: Defence Jobs	2012 Means of samples: Non-Defence Jobs	2012 Means of samples: Matched Jobs	2012 Bias in matched sample (%)	2013 Means of samples: Defence Jobs	2013 Means of samples: Non-Defence Jobs	2013 Means of samples: Matched Jobs	2013 Bias in matched sample (%)	2014 Means of samples: Defence Jobs	2014 Means of samples: Non-Defence Jobs	2014 Means of samples: Matched Jobs	2014 Bias in matched sample (%)
Knowledge	Humanities, Law, Education and Chemistry	-0.15	0.06	-0.19	5.40	-0.11	0.06	-0.09	-1.80	-0.11	0.05	-0.14	4.10
	Science, Econ, Computer, Languages, Arts & Geography	0.70	-0.10	0.70	-0.40	0.76	-0.10	0.79	-2.60	0.75	-0.11	0.75	-0.30
	Engineering, Education, Public safety, Food production	0.10	0.18	0.15	-4.70	0.16	0.18	0.13	3.70	0.17	0.16	0.21	-3.50
	Telecom, Mechanical, Personnel and human resources	0.58	0.13	0.70	-11.90	0.57	0.13	0.60	-3.10	0.53	0.12	0.55	-2.40
	Transportation, Philosophy and Theology	-0.19	-0.04	-0.26	6.80	-0.21	-0.05	-0.24	2.60	-0.21	-0.04	-0.26	5.90
	Psychology, Biology, Sociology and Anthropology	-0.26	-0.07	-0.27	0.50	-0.24	-0.07	-0.23	-0.90	-0.24	-0.08	-0.24	0.00
	Clerical, Therapy and counselling	-0.16	-0.08	-0.13	-2.90	-0.13	-0.07	-0.11	-1.80	-0.14	-0.07	-0.10	-3.40
	Mathematics knowledge	-0.29	-0.17	-0.21	-9.90	-0.29	-0.17	-0.25	-5.90	-0.30	-0.17	-0.33	4.20
	Physics knowledge	-0.08	-0.01	-0.12	0.00	-0.05	0.00	-0.08	0.00	-0.06	0.00	-0.04	0.00

Sensitivity Tests

The analysis may be biased if there are unobservable variables that drive selection into the defence sector, as well as the outcome in terms of any pay premium. One approach to test for the potential impact of unobserved variables is the Rosenbaum-bounds method. It assesses "how strongly an unmeasured confounding variable must affect selection into treatment in order to undermine the conclusions about causal effects from matching analysis" (DiPrete and Gangl, 2004). Different levels of hidden bias can be expressed in terms of the odds ratio, gamma (Γ), of two matched observations being treated. If matching is unbiased, observations with the same observable characteristics have the same probability of being treated. When Γ=2, an unmeasured confounding variable causes one observation to be twice as likely to be selected into treatment as the matched observation with the same observable characteristics (Peel and Makepeace, 2009).

The method then does the following. It assumes that there is a known factor causing bias to the level of Γ, and that the treatment effect from this bias can be stripped out. Once this is done, it is tested whether the treatment effect remains significant. In this fashion, starting with zero bias, the treatment effect can be computed and the assumption of ever larger bias tested.

The panels of Table B4 give the Rosenbaum bounds estimation for different matching models used in this study. For different levels of Γ, it gives the upper and lower point estimates of the treatment effects, under the assumption of negative and positive selection bias, respectively. It also gives significance levels for these estimates under the null-hypothesis that the true treatment effect is zero at a certain level of positive or negative bias. The upper and lower point estimates can be interpreted in terms of a – usually – increasing cone of possible values as Γ rises. Where the cone begins to include zero, this is the level of bias where results are no longer robust.

The results for each year about the defence jobs indicate the level of bias would have to quite high before the estimated wage premium, used as the outcome variable, would be significantly different from that estimated were no bias assumed. This suggests the results are robust. The results for the aviation and maritime sample of defence jobs are less clear cut. At modest levels of bias, the PSM matches would give different results about wage premiums between the identified defence jobs and the wider set of jobs.

Apart from the underlying matching being problematic, there is another explanation for this: the sample size in these groups becomes quite small. The problem is that the wage premium estimates may not be very robust

Table B4.1: Rosenbaum bounds test for 2012

	All Defence Jobs								Sectoral defence jobs							
	Wider definition of defence				Narrow definition of defence				Maritime				Combat Air			
	Significance of selection effect		Point estimate		Significance of selection effect		Point estimate		Significance of selection effect		Point estimate		Significance of selection effect		Point estimate	
Γ	Positive	Negative	Upper	Lower	Positive	Negative	Upper	Lower	Positive	Negative	Upper	Lower	Positive	Negative	Upper	Lower
1.00	0.02	0.02	0.05	0.05	0.00	0.00	0.10	0.10	0.14	0.14	-0.11	-0.11	0.42	0.42	-0.01	-0.01
1.02	0.03	0.01	0.05	0.06	0.00	0.00	0.09	0.10	0.14	0.15	-0.11	-0.11	0.39	0.44	-0.01	-0.01
1.04	0.05	0.01	0.04	0.06	0.00	0.00	0.09	0.11	0.13	0.16	-0.12	-0.10	0.37	0.46	-0.02	-0.01
1.06	0.07	0.00	0.04	0.07	0.01	0.00	0.08	0.11	0.12	0.17	-0.12	-0.10	0.35	0.48	-0.02	0.00
1.08	0.10	0.00	0.03	0.07	0.01	0.00	0.07	0.12	0.11	0.18	-0.13	-0.10	0.33	0.50	-0.02	0.00
1.10	0.15	0.00	0.03	0.08	0.01	0.00	0.07	0.12	0.11	0.19	-0.13	-0.10	0.31	0.53	-0.03	0.00
1.12	0.20	0.00	0.02	0.08	0.02	0.00	0.06	0.13	0.10	0.19	-0.13	-0.10	0.30	0.55	-0.03	0.01
1.14	0.26	0.00	0.02	0.09	0.03	0.00	0.06	0.13	0.10	0.20	-0.13	-0.10	0.28	0.57	-0.04	0.01
1.16	0.32	0.00	0.01	0.09	0.04	0.00	0.05	0.14	0.09	0.21	-0.13	-0.09	0.26	0.59	-0.04	0.01
1.18	0.39	0.00	0.01	0.10	0.06	0.00	0.05	0.14	0.09	0.22	-0.13	-0.09	0.25	0.61	-0.05	0.02
1.20	0.47	0.00	0.00	0.10	0.08	0.00	0.04	0.15	0.08	0.23	-0.14	-0.09	0.23	0.62	-0.05	0.02
1.30	0.79	0.00	-0.02	0.12	0.24	0.00	0.02	0.17	0.06	0.27	-0.15	-0.08	0.17	0.71	-0.07	0.05
1.40	0.95	0.00	-0.04	0.14	0.48	0.00	0.00	0.19	0.05	0.32	-0.16	-0.07	0.12	0.78	-0.08	0.07
1.50	0.99	0.00	-0.06	0.16	0.72	0.00	-0.02	0.21	0.03	0.36	-0.16	-0.06	0.08	0.83	-0.10	0.08

Table B4.2: Rosenbaum bounds test for 2013

	All Defence Jobs								Sectoral defence jobs							
	Wider definition of defence				Narrow definition of defence				Maritime				Combat Air			
	Significance of selection effect		Point estimate		Significance of selection effect		Point estimate		Significance of selection effect		Point estimate		Significance of selection effect		Point estimate	
Γ	Positive	Negative	Upper	Lower	Positive	Negative	Upper	Lower	Positive	Negative	Upper	Lower	Positive	Negative	Upper	Lower
1.00	0.00	0.00	0.10	0.10	0.00	0.00	0.09	0.09	0.01	0.01	0.18	0.18	0.31	0.31	0.03	0.03
1.02	0.00	0.00	0.10	0.11	0.00	0.00	0.08	0.10	0.01	0.00	0.18	0.19	0.33	0.29	0.03	0.04
1.04	0.00	0.00	0.09	0.12	0.00	0.00	0.08	0.10	0.01	0.00	0.17	0.19	0.36	0.27	0.02	0.04
1.06	0.00	0.00	0.09	0.12	0.01	0.00	0.07	0.11	0.01	0.00	0.17	0.20	0.38	0.25	0.02	0.05
1.08	0.00	0.00	0.08	0.13	0.01	0.00	0.07	0.11	0.01	0.00	0.16	0.20	0.40	0.24	0.02	0.05
1.10	0.00	0.00	0.08	0.13	0.02	0.00	0.06	0.12	0.02	0.00	0.16	0.21	0.42	0.22	0.02	0.05
1.12	0.00	0.00	0.07	0.14	0.03	0.00	0.06	0.12	0.02	0.00	0.15	0.22	0.44	0.20	0.01	0.06
1.14	0.00	0.00	0.07	0.14	0.04	0.00	0.05	0.13	0.02	0.00	0.15	0.22	0.46	0.19	0.01	0.06
1.16	0.00	0.00	0.06	0.15	0.05	0.00	0.05	0.13	0.03	0.00	0.15	0.22	0.48	0.18	0.00	0.06
1.18	0.01	0.00	0.06	0.15	0.07	0.00	0.04	0.13	0.03	0.00	0.14	0.23	0.50	0.16	0.00	0.07
1.20	0.01	0.00	0.05	0.16	0.10	0.00	0.04	0.14	0.03	0.00	0.14	0.24	0.52	0.15	-0.01	0.08
1.30	0.11	0.00	0.03	0.18	0.29	0.00	0.02	0.16	0.07	0.00	0.11	0.26	0.62	0.10	-0.02	0.10
1.40	0.35	0.00	0.01	0.20	0.56	0.00	0.00	0.18	0.11	0.00	0.09	0.28	0.70	0.07	-0.04	0.12
1.50	0.67	0.00	-0.01	0.22	0.78	0.00	-0.02	0.20	0.17	0.00	0.07	0.30	0.76	0.04	-0.05	0.13

Table B4.3: Rosenbaum bounds test for 2014

	All Defence Jobs								Sectoral defence jobs							
	Wider definition of defence				Narrow definition of defence				Maritime				Combat Air			
	Significance of selection effect		Point estimate		Significance of selection effect		Point estimate		Significance of selection effect		Point estimate		Significance of selection effect		Point estimate	
Γ	Positive	Negative	Upper	Lower	Positive	Negative	Upper	Lower	Positive	Negative	Upper	Lower	Positive	Negative	Upper	Lower
1.00	0.00	0.00	0.06	0.06	0.00	0.00	0.10	0.10	0.00	0.00	0.22	0.22	0.00	0.00	0.19	0.19
1.02	0.01	0.00	0.06	0.07	0.00	0.00	0.10	0.11	0.00	0.00	0.21	0.22	0.00	0.00	0.18	0.19
1.04	0.01	0.00	0.05	0.07	0.00	0.00	0.09	0.11	0.00	0.00	0.21	0.23	0.00	0.00	0.18	0.20
1.06	0.02	0.00	0.05	0.08	0.00	0.00	0.09	0.12	0.00	0.00	0.20	0.23	0.00	0.00	0.17	0.20
1.08	0.04	0.00	0.04	0.08	0.00	0.00	0.08	0.12	0.01	0.00	0.20	0.24	0.00	0.00	0.17	0.21
1.10	0.06	0.00	0.04	0.09	0.01	0.00	0.08	0.13	0.01	0.00	0.19	0.24	0.00	0.00	0.16	0.21
1.12	0.09	0.00	0.03	0.10	0.01	0.00	0.07	0.13	0.01	0.00	0.19	0.25	0.01	0.00	0.16	0.21
1.14	0.13	0.00	0.03	0.10	0.02	0.00	0.07	0.14	0.01	0.00	0.18	0.25	0.01	0.00	0.15	0.22
1.16	0.18	0.00	0.02	0.11	0.02	0.00	0.06	0.14	0.01	0.00	0.18	0.26	0.01	0.00	0.15	0.22
1.18	0.23	0.00	0.02	0.11	0.03	0.00	0.06	0.15	0.01	0.00	0.17	0.26	0.01	0.00	0.14	0.23
1.20	0.30	0.00	0.01	0.11	0.05	0.00	0.05	0.15	0.01	0.00	0.17	0.26	0.01	0.00	0.14	0.23
1.30	0.67	0.00	-0.01	0.14	0.18	0.00	0.03	0.18	0.03	0.00	0.15	0.28	0.03	0.00	0.11	0.26
1.40	0.91	0.00	-0.03	0.16	0.41	0.00	0.01	0.20	0.04	0.00	0.13	0.31	0.06	0.00	0.10	0.27
1.50	0.98	0.00	-0.05	0.18	0.67	0.00	-0.01	0.22	0.07	0.00	0.11	0.33	0.09	0.00	0.08	0.29

Annex C: Additional Tables

In the report, tables often focus on particular years. This annex gives a complete set of results for the three years of ASHE used: 2012, 2013 and 2014.

Summary Statistics, 2012-14

Table C1.1: Summary statistics, 2012

		All businesses			Defence businesses
Variables	**Unit**	**Mean**	**s.d.**	**Observations**	**Mean**
Gross pay	Log	6.219	0.509	117012	6.460
Age	Year	40.9	11.9	117039	43.18
Gender (female=1)	Proportion	0.41	0.49	117039	0.18
Total hours	Hours per week	39.06	5.93	117039	39.46
Average capital expenditure, all assets	3-yr log average	3.89	40.52	116944	6.45
Defence businesses (=1)	Proportion	0.007	0.084	117039	1.00
Manufacturing (=1)	Proportion	0.119	0.323	108997	0.67
Defence prime (=1)	Proportion	0.002	0.046	117039	0.30
Shortage occupation (=1)	Proportion	0.39	0.24	109760	0.45
Private sector (=1)	Proportion	0.68	0.47	117039	1.00
Employment	Jobs	15351	38245	117030	5732
Log Employment	Log	7.08	2.84	116935	7.10
Size (Large=1)	Proportion	0.62	0.49	117039	0.58
London	Proportion	0.16	0.37	117039	0.04
Southeast	Proportion	0.13	0.34	117039	0.27
Skills Factor	**Unit**	**Mean**	**s.d.**	**Observations**	**Mean**
People, Systems and Operations	Factor score	0.175	0.971	108997	0.01
Materials, Equipment & Technical	Factor score	-0.186	0.973	108997	0.44
Programming and equipment	Factor score	-0.030	0.910	108997	0.75
Coordination and Persuasion	Factor score	0.064	1.066	108997	0.23
Active learning skills	Factor score	0.054	0.933	108997	0.34
Analysing, processing information, consulting, advising	Factor score	0.016	1.106	108997	0.06
Problem solving, negotiating, control, planning & prioritising	Factor score	0.172	0.783	108997	0.55
Handling, inspecting objects, machines and vehicles, coordinating people	Factor score	-0.168	0.950	108997	0.25
Monitoring processes, materials and surroundings and selling and influencing	Factor score	0.177	0.986	108997	-0.51
Coaching people, inspecting equipment & structures and selling & influencing	Factor score	-0.067	1.063	108997	0.00
Humanities, Law, Education and Chemistry	Factor score	0.088	1.069	108997	-0.13
Science, Econ, Computer, Languages, Arts & Geography	Factor score	-0.094	0.980	108997	0.69
Engineering, Education, Public safety, Food production	Factor score	0.162	1.087	108997	0.08
Telecom, Mechanical, Personnel and human resources	Factor score	0.151	0.873	108997	0.55
Transportation, Philosophy and Theology	Factor score	0.000	0.928	108997	-0.13
Psychology, Biology, Sociology and Anthropology	Factor score	-0.073	0.956	108997	-0.29
Clerical, Therapy and counselling	Factor score	-0.087	0.929	108997	-0.18
Mathematics knowledge	Factor score	-0.191	0.914	108997	-0.28
Physics knowledge	Factor score	-0.007	0.939	108997	-0.08

Table C1.2: Summary statistics, 2013

		All businesses			Defence businesses
Variables	**Unit**	**Mean**	**s.d.**	**Observations**	**Mean**
Gross pay	Log	6.233	0.509	118908	6.480
Age	Year	41.0	11.9	118932	43.29
Gender (female=1)	Proportion	0.41	0.49	118932	0.17
Total hours	Hours per week	39.05	5.79	118932	38.81
Average capital expenditure, all assets	3-yr log average	3.44	19.02	118880	6.07
Defence businesses (=1)	Proportion	0.008	0.089	118932	1.00
Manufacturing (=1)	Proportion	0.121	0.326	110709	0.66
Defence prime (=1)	Proportion	0.002	0.050	118932	0.31
Shortage occupation (=1)	Proportion	0.39	0.24	111589	0.44
Private sector (=1)	Proportion	0.69	0.46	118932	0.99
Employment	Jobs	14878	38001	118912	5318
Log Employment	Log	7.07	2.81	118865	7.17
Size (Large=1)	Proportion	0.62	0.48	118932	0.63
London	Proportion	0.16	0.37	118932	0.05
Southeast	Proportion	0.13	0.34	118932	0.20
Skills Factor	**Unit**	**Mean**	**s.d.**	**Observations**	**Mean**
People, Systems and Operations	Factor score	0.172	0.974	110709	0.07
Materials, Equipment & Technical	Factor score	-0.187	0.976	110709	0.46
Programming and equipment	Factor score	-0.023	0.920	110709	0.74
Coordination and Persuasion	Factor score	0.062	1.068	110709	0.27
Active learning skills	Factor score	0.055	0.934	110709	0.39
Analysing, processing information, consulting, advising	Factor score	0.015	1.105	110709	0.14
Problem solving, negotiating, control, planning & prioritising	Factor score	0.173	0.785	110709	0.54
Handling, inspecting objects, machines and vehicles, coordinating people	Factor score	-0.171	0.951	110709	0.27
Monitoring processes, materials and surroundings and selling and influencing	Factor score	0.176	0.992	110709	-0.53
Coaching people, inspecting equipment & structures and selling & influencing	Factor score	-0.071	1.067	110709	0.01
Humanities, Law, Education and Chemistry	Factor score	0.093	1.070	110709	-0.09
Science, Econ, Computer, Languages, Arts & Geography	Factor score	-0.094	0.982	110709	0.75
Engineering, Education, Public safety, Food production	Factor score	0.160	1.086	110709	0.14
Telecom, Mechanical, Personnel and human resources	Factor score	0.148	0.871	110709	0.53
Transportation, Philosophy and Theology	Factor score	-0.009	0.924	110709	-0.09
Psychology, Biology, Sociology and Anthropology	Factor score	-0.075	0.953	110709	-0.28
Clerical, Therapy and counselling	Factor score	-0.079	0.933	110709	-0.17
Mathematics knowledge	Factor score	-0.190	0.912	110709	-0.30
Physics knowledge	Factor score	-0.002	0.946	110709	-0.06

Table C1.3: Summary statistics, 2014

		All businesses			Defence businesses
Variables	**Unit**	**Mean**	**s.d.**	**Observations**	**Mean**
Gross pay	Log	6.235	0.511	121540	6.505
Age	Year	40.9	12.1	121573	43.63
Gender (female=1)	Proportion	0.41	0.49	121573	0.17
Total hours	Hours per week	39.17	6.52	121573	39.31
Average capital expenditure, all assets	3-yr log average	3.29	22.83	121508	5.59
Defence businesses (=1)	Proportion	0.008	0.089	121573	1.00
Manufacturing (=1)	Proportion	0.119	0.323	113298	0.64
Defence prime (=1)	Proportion	0.002	0.048	121573	0.29
Shortage occupation (=1)	Proportion	0.39	0.24	114298	0.44
Private sector (=1)	Proportion	0.71	0.46	121573	0.99
Employment	Jobs	13968	36247	121545	4335
Log Employment	Log	7.00	2.81	121495	7.08
Size (Large=1)	Proportion	0.61	0.49	121573	0.64
London	Proportion	0.16	0.37	121573	0.05
Southeast	Proportion	0.14	0.34	121573	0.22
Skills Factor	**Unit**	**Mean**	**s.d.**	**Observations**	**Mean**
People, Systems and Operations	Factor score	0.155	0.974	113298	0.07
Materials, Equipment & Technical	Factor score	-0.186	0.975	113298	0.48
Programming and equipment	Factor score	-0.033	0.922	113298	0.72
Coordination and Persuasion	Factor score	0.057	1.057	113298	0.27
Active learning skills	Factor score	0.056	0.931	113298	0.40
Analysing, processing information, consulting, advising	Factor score	0.006	1.096	113298	0.15
Problem solving, negotiating, control, planning & prioritising	Factor score	0.160	0.789	113298	0.53
Handling, inspecting objects, machines and vehicles, coordinating people	Factor score	-0.167	0.952	113298	0.29
Monitoring processes, materials and surroundings and selling and influencing	Factor score	0.177	0.989	113298	-0.52
Coaching people, inspecting equipment & structures and selling & influencing	Factor score	-0.073	1.068	113298	-0.01
Humanities, Law, Education and Chemistry	Factor score	0.081	1.066	113298	-0.08
Science, Econ, Computer, Languages, Arts & Geography	Factor score	-0.100	0.979	113298	0.75
Engineering, Education, Public safety, Food production	Factor score	0.146	1.082	113298	0.15
Telecom, Mechanical, Personnel and human resources	Factor score	0.136	0.875	113298	0.49
Transportation, Philosophy and Theology	Factor score	-0.005	0.924	113298	-0.10
Psychology, Biology, Sociology and Anthropology	Factor score	-0.081	0.949	113298	-0.27
Clerical, Therapy and counselling	Factor score	-0.075	0.929	113298	-0.17
Mathematics knowledge	Factor score	-0.184	0.910	113298	-0.30
Physics knowledge	Factor score	-0.006	0.950	113298	-0.06

Weekly Pay for Defence and all Jobs, 2013-14

Table C2.1: Defence and non-Defence Weekly Pay Averages for 2013

			Different pay measures drawing from ASHE		
	Number of jobs	Weekly hours	Gross Pay	Basic Pay	Gross excl Overtime
Defence jobs	**957**	**38.9**	**£718.35**	**£641.78**	**£687.23**
Maritime jobs	83	39.9	£730.90	£599.27	£674.71
Aviation jobs	111	37.9	£730.40	£586.12	£681.42
ALL JOBS	118912	39.1	£590.25	£545.64	£573.75

Table C2.2: Defence and non-Defence Weekly Pay Averages for 2014

			Different pay measures drawing from ASHE		
	Number of jobs	Weekly hours	Gross Pay	Basic Pay	Gross excl Overtime
Defence jobs	**960**	**39.3**	**£732.77**	**£659.71**	**£699.03**
Maritime jobs	84	40.5	£756.78	£611.49	£692.64
Aviation jobs	136	38.6	£835.23	£719.36	£798.41
ALL JOBS	121573	39.2	£591.46	£548.40	£574.88

Defence Jobs by Region, 2013-14

Table C3: ASHE Full-Time Defence and non-Defence Jobs by Region, 2013-14

GOR	Description	2013		2014	
		All jobs	Defence jobs	All jobs	Defence jobs
1	North East	4,777	16	4,882	25
2	North West	13,267	144	13,427	153
3	Yorkshire and The Humber	9,760	24	9,875	22
4	East Midlands	8,716	42	8,824	76
5	West Midlands	10,508	72	10,809	58
6	South West	9,595	140	9,784	140
7	East	10,679	83	10,965	72
8	London	19,307	37	19,889	44
9	South East	15,935	218	16,442	203
10	Wales	5,431	72	5,573	69
11	Scotland	10,957	109	11,103	98
TOTAL		**118,932**	**957**	**121,573**	**960**

Jobs by Occupation, 2013-14

Table C4.1: ASHE Full-Time Defence and non-Defence Jobs by Occupation, 2013

SOC	Description	Defence	Of which:		All jobs	Defence jobs
			Marine	Air		
11	Corporate Managers And Directors	84	**	15	6,993	1.2%
21	Science, Research, Engineering And Technology Professionals	204	10	10	5,673	3.6%
24	Business, Media And Public Service Professionals	38	**	**	5,040	0.8%
25		20	**	**	1,177	1.7%
31	Science, Eng'ing & Tech Ass Prof'nals	75	**	**	3,501	2.1%
35	Business And Public Service Associate Professionals	68	**	**	8,093	0.8%
36		12	0	**	2,269	0.5%
41	Administrative Occupations	41	**	**	7,653	0.5%
42	Secretarial And Related Occupations	53	**	**	8,517	0.6%
52	Skilled Metal, Elec'l/Electronic Trades	159	34	37	5,125	3.1%
53	Skilled Construction & Building Trades	14	**	**	1,937	0.7%
81	Process, Plant & Machine Operatives	72	10	**	4,921	1.5%
82	Transport Drivers And Operatives	24	0	**	4,595	0.5%
91	Elementary Trades, Administration, Service And Related Occupations	13	**	**	2,438	0.5%
93		29	0	**	6,091	0.5%
All	All Occupations	957	83	111	118,932	0.8%

Table C4.2: ASHE Full-Time Defence and non-Defence Jobs by Occupation, 2014

SOC	Description	Defence	Of which:		All jobs	Defence jobs
			Marine	Air		
11	Corporate Managers And Directors	82	12	16	6,988	1.2%
21	Science, Research, Engineering And Technology Professionals	197	**	30	5,778	3.4%
24	Business, Media And Public Service Professionals	39	**	**	5,206	0.7%
25		21	**	**	1,240	1.7%
31	Science, Eng'ing & Tech Ass Prof'nals	77	**	**	3,493	2.2%
35	Business And Public Service Associate Professionals	66	**	**	8,297	0.8%
36		15	**	**	2,283	0.7%
41	Administrative Occupations	36	**	**	7,317	0.5%
42	Secretarial And Related Occupations	47	**	**	8,835	0.5%
52	Skilled Metal, Elec'l/Electronic Trades	159	25	42	5,202	3.1%
53	Skilled Construction & Building Trades	14	**	**	1,901	0.7%
81	Process, Plant & Machine Operatives	78	**	**	4,880	1.6%
82	Transport Drivers And Operatives	23	0	**	4,779	0.5%
91	Elementary Trades, Administration, Service And Related Occupations	17	**	0	2,593	0.7%
93		37	**	**	7,011	0.5%
All	All Occupations	960	84	136	121,573	0.8%

References

Abowd, J.M., Kramarz, F., Lengermann, P., McKinney, K.L., & Roux, S. (2013) Persistent inter-industry wage differences: Rent sharing and opportunity costs. *IZA Journal of Labour Economics*, vol. 1, no. 1., pp. 1-25.

Barrett, A. & O'Connell, P.J. (2001). Is there a wage premium for returning Irish migrants? *The Economic and Social Review*, vol. 32, no. 1, pp. 1-21.

BIS (2016) *Evaluating business support interventions: A productivity based approach.* BIS Research Paper BIS/16/311.

Bryson, A. (2002). The union membership wage premium: an analysis using propensity score matching. *Centre for Economic Performance*.

Cappelli, P. & Chauvin, K. (1991). An interplant test of the efficiency wage hypothesis. *The Quarterly Journal of Economics*, vol. 106, no. 3, pp. 769-787.

Chiswick, B.R. (2003). "Jacob Mincer, Experience and the Distribution of Earnings." IZA Discussion Paper No. 847, Bonn.

Currie, D. (2011) 'Review of Single Source Pricing Regulations". Independent report to Ministry of Defence, London.

Damant, Andrew and Jamie Jenkins (2011) "Estimating differences in public and private sector pay". Report by the Office for National Statistics, https://www.nomisweb.co.uk/articles/ref/stories/8/public_private_sector_pay_july2011.pdf

Davies, N., Eager, E., Maier, M., and Penfold, L. (2012). Intergenerational equipment cost escalation. Defence Economics Research Paper for the Ministry of Defence.

Dickerson, A., R. Wilson, G. Kik and D. Dhillon (2012) *Developing Occupational Skills Profiles for the UK: A Feasibility Study*, Evidence Report 44 to the UK Commission for Employment and Skills, February.

Disney, R., & Gosling, A. (1998). Does it pay to work in the public sector? *Fiscal Studies*, vol. 19 no. 4.

Disney, R.F., & Gosling, A. (2003). A new method for estimating public sector pay premia: Evidence from Britain in the 1990s. *CEPR discussion paper* no. 3787.

Dorman, A., Uttley, M., and Wilkinson, B. (2015). A benefit, not a burden: The security, economic and strategic value of Britain's defence industry. London, UK: King's College Policy Institute.

Gibbons, R. & Katz, L. (1989). Does unmeasured ability explain inter-industry wage differences? *NBER working paper* no. 1989.

Girma, S. and Goerg, H. (2006). Evaluating the foreign ownership wage premium using a difference-in-differences matching approach. *CEPR discussion paper* no. 5788.

Heckman, J., R. LaLonde, and J. Smith (1999) "The Economics and Econometrics of Active Labor Market Programs". Chapter of the Handbook of Labor Economics Vol III, ed. Ashenfelter, O. and D. Card.

HMG & DGP (2014) "Delivering growth – Implementing the strategic vision for the UK defence sector)." Report by HM government and the Defence Growth Partnership, July.

IDS (2011) "Public and private sector earnings: fact and fiction", IDS Pay Report no. 1075, July.

Kleibrink, J and M. Michaelsen (2011) "Reaching High: Occupational Sorting and Higher Education Wage Inequality in the UK". Ruhr Economic Papers 377.

Krug, G., & Nisic, N. (2011). Is there an urban wage premium for women? A difference-in-difference analysis using propensity score matching*. Labor and Socio-Economic Research Centre University of Erlangen-Nuremberg discussion paper* no. 54.

Matano, A., & Naticchioni, P. (2013) What drives the urban wage premium? Evidence along the wage distribution. *IZA discussion paper* no. 7811.

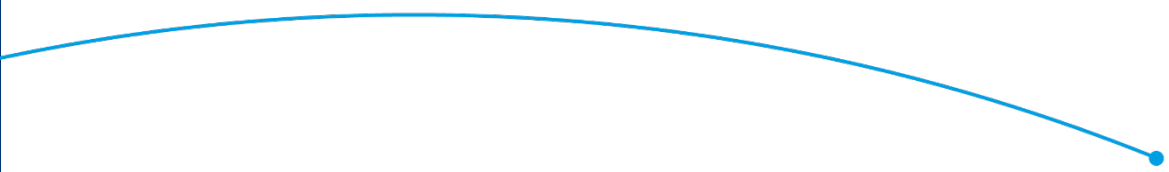
Mumford, K., and Smith, P.N. (2004). The gender earnings gap in Britain. IZA Discussion Paper no. 1109.

ONS (2014). "Public and private sector earnings". Report by the Office for National Statistics, November.

Retter, L., L. Taggart and J. Freeman (2015) 'Key Skills and Competencies in Defence" Report to European Defence Agency by RAND Europe.

Rosenbaum, P. (2002). *Observation Studies*, New York: Springer.

Troske, K.R. (1994). Evidence on the employer size-wage premium from worker-establishment matched data. *Centre for Economic Studies working paper* no. 94-10.



This publication is available from: www.gov.uk/beis

Contacts us if you have any enquiries about this publication, including requests for alternative formats, at: enquiries@beis.gov.uk